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Functional Description

for

Windows Integrated Logistics Assessment Model (WINLAM) Funding/Availability Multi-Method Allocator for Spares (FAMMAS)

Prepared for

HQ USAF/LGSI
1030 Air Force Pentagon
Washington, DC 20330-1030

1 June 1995

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FOR THE COMMANDER

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This functional description for the Windows Integrated Logistics Assessement Model(WINLAM) and the Funding/Availability Multi-Method Allocator for Spares model(FAMMAS) provides the following information: System requirements that will serve as a basis for mutual understanding between the user and the developer; Information on performace requirements, preliminary design, and user impacts; and a basis for the development of system tests.

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LIST OF ACRONYMS

AAM	Aircraft Availability Model
ABACUS	Automated Budget Analysis Centralized System
ABIDES	Automated Budget Interactive Data Environment System
ACC	Air Combat Command
ADP	Automated data processing
AFB	Air Force Board
AFBS	Air Force Board Structure
AFC	Air Force Council
AFCAIG	Air Force Cost Analysis Improvement Group
AFCC	Air Force Cost Center
AFMC	Air Force Materiel Command
AFP	Air Force Pamphlet
AFPG	Air Force Planning Guide
AFR	Air Force Regulation
AFWMAA/DSS	Air Force-Wide Mission Area Analysis/Decision Support System
AIS	Automated information system
ALAM	Airlift Systems Logistics Assessment Model
ALOC	Air Line of Communication
AMC	Air Mobility Command
ARLAM	Aerial Refueling Systems Logistics Assessment Model
ASCII	American Standard Code for Information Interchange
BAI	Backup aircraft inventory
BES	Budget Estimate Submission
BLSS	Base-level self-sufficiency spares
BOS	Base operating support
BPPBS	Biennial Planning, Programming, and Budgeting System
CINC	Commander in chief
CONUS	Continental United States
CORE	Cost-Oriented Resource Estimating
CPU	Central processing unit
DBMS	Database management system
DCS	Deputy Chief of Staff
DG	Defense Guidance

DLR	Depot-level reparable
DMIF	Depot maintenance industrial fund
DMM	Data Management Module
DOD	Department of Defense
DPEM	Depot-purchased equipment maintenance
DRIVE	Distribution and Repair in Variable Environments
DSO	Direct support objective
DSS	Decision support system
DTAS	Decision Tracking and Analysis System
EGA	Enhanced graphics adaptor
FAMMAS	Funding/Availability Multi-Method Allocation for Spares
FAS	Force Assessment System
FD	Functional Description
FDB	Functional description baseline
F&FP	Force and Financial Plan
FMC	Fully mission capable
FMS	File Management System
FP	Force Projection
FRM	Force Readiness Module
FY	Fiscal year
FYDP	Future-Year Defense Program
GPM	Global Power Module
GR-GP	Global Reach-Global Power
GRM	Global Reach Module
GSD	General Support Division
HQ USAF	Headquarters, U.S. Air Force
ILAM	Integrated Logistics Assessment Model
JSCP	Joint Strategic Capabilities Plan
KB	Kilobyte or approximately 1,000 characters of storage
LAM	Logistics Assessment Model
LCMS	Logistics Capability Measurement System
LCOM	Logistics Composite Model
MAJCOM	Major command
MB	Megabyte (approximately 1,000,000 characters of storage)
MC	Mission capable

MD	Mission, design
MDS	Mission, design, series
MHE	Materiel handling equipment
MOE	Measure of effectiveness
MS-DOS	Microsoft Corporation Disk Operating System
MTBF	Mean time between failure
MTTR	Mean time to repair
MULTICS	Multiplexed Information and Computing Service
NATO	North Atlantic Treaty Organization
NLMR	Nonlinear marginal return
NMC	Not mission capable
NMCB	Not mission capable, both
NMCM	Not mission capable, maintenance
NMCS	Not mission capable, supply
O&M	Operations and Maintenance
OPLAN	Operation Plan
OPS	Operations
OPR	Office of primary responsibility
OPTEMPO	Operating tempo
O&S	Operating and Support
OSD	Office of the Secretary of Defense
OST	Order and ship time
OWRM	Other war reserve materiel
PA	Program authority
PAA	Primary aircraft authorized
PAT	Peacetime availability target
PB	President's Budget
PBD	Program budget decision
PCS	Permanent change of station
PDP	Program decision package
PDS	Program Data System
PE	Program element
PEM	Program element monitor
PMRT	Program management responsibility transfer
POC	Point of contact

POL	Petroleum, oil, and lubricants
POM	Program Objective Memorandum
POS	Primary operating stock
PPBS	Planning, Programming, and Budgeting System
PSE	Partial sortie effectiveness
RAM	Random access memory
REMIS	Reliability and Maintainability Information System
RSD	Reparable Support Division
RSP	Readiness Spares Package
SABLE	Systematic Approach to Better Long-Range Estimating
SAM	Sustainability Assessment Module
SPD	System program director
SPM	System program manager
SSD	System Support Division
SWAP	Spares Wartime Assessment Procedure
TAI	Total aircraft inventory
TLAM	Tactical Systems Logistics Assessment Model
TNMCM	Total not mission capable, maintenance
TNMCS	Total not mission capable, supply
UCD	Unit cost document
USAF	United States Air Force
UTE	Airlift aircraft utilization
VGA	Video graphics adaptor
WMP	War and Mobilization Plan
WMP-4	War and Mobilization Plan, Volume 4
WMP-5	War and Mobilization Plan, Volume 5
WRM	War reserve materiel (now RSP)
WSMIS	Weapon System Management Information System
WSMP	Weapon System Master Plan
WSPAR	Weapon System Program Review
WSPDP	Weapon System Program Decision Package

EXECUTIVE SUMMARY

The Air Force urgently needs a logistics resource assessment system. There is a continuous need to justify and balance expenditures that sustain operational capability.

Historically, modeling has been used to help justify necessary expenditures, perhaps because it is the most successful vehicle for gathering and structuring costs and operational data. Refinement of modeling techniques, when coupled with the improved capabilities of microcomputers, has made possible a new generation of fast, portable models that can provide analysts with authoritative, reliable information on the impact of funding options in time to influence budget decisions.

In the course of developing an approach for quickly assessing the impact of programming and budgeting decisions on capability, Synergy designed a set of parametric models for macro-level logistics budget analyses for the United States Air Force, Deputy Chief of Staff Logistics, and Deputy Chief of Staff for Plans and Operations. Initially, two separate sustainability models were developed to support capability assessment in the Air Force Mission Area Analysis/Decision Support System.

These were known as the Tactical Systems Logistics Assessment Model (TLAM) and the Airlift Systems Logistics Assessment Model (ALAM), which were designed to measure sustainability. A third model, the Funding/Availability Multi-Method Allocation for Spares (FAMMAS), was developed to broaden the base of resource assessment throughout the programming and budgeting process by measuring weapon system readiness. FAMMAS generates a peacetime aircraft availability rate and operates in tandem with ALAM and TLAM to provide the Air Force with a system of analytical tools to perform rapid trade-offs across nearly all major operating and support cost programs.

The demonstrated success of these fast, portable models led to a requirement to formally integrate them to facilitate their use during the planning, programming, and budgeting cycle. This effort involves establishing a production-oriented database and integrating the models for simplified use by logistics analysts. The resulting Windows Integrated Logistics Assessment Model (WINLAM) is designed to function as a production model. It consists of a Data Management Module, a Force Readiness Module, a Global Power Module, and a Global Reach Module.

The Data Management Module supports the operation of the assessment modules by permitting the selection, editing, viewing, transfer, and saving of information on weapon system resource profiles by weapon system code, mission design, program element, and/or major command (MAJCOM).

The Force Readiness Module (FRM) performs materiel readiness assessments. The FRM currently consists of two programs for assessment of peacetime operations. FAMMAS develops assessments of aircraft availability based on funding projections for replenishment spares (Reparable Support Division) and consumables (System Support Division). A peacetime operational status report has also been implemented that summarizes aircraft quantities, availability, and sortie generation capability by MD.

The Global Power Module, which contains TLAM, receives information from the FRM to initialize the peacetime availability rate for the weapon system under consideration. It then estimates the impact on combat aircraft availability of flying wartime surge and sustained sortie rates. This module contains both a supply and maintenance function to estimate mission capable rates. Degradation due to consumption of logistics resources is estimated by a set of parametric equations. Using data on scheduled wartime sortie rates, the model attempts to fly the assigned sorties. Resources are consumed daily and remaining resource levels at the end of each day determine the number of available aircraft projected for the next day. The program operates on as many as three combat theaters at a time. A day-by-day picture of the weapon system's performance during deployment and engagement is presented in tables and graphs.

The Global Reach Module, which contains ALAM, operates like the Global Power Module but uses resource data to predict utilization rates for airlift aircraft. A series of parametric variables is calibrated and then used to track the impact on utilization rate of resource consumption over time.

Taken together, these modules can quickly assess the operational impact of proposed changes in the funding of logistics resources. The vast capability of this integrated model can trace its origins to years of evolutionary improvements in Air Force cost analysis and the detailed modeling of logistics processes. Yet it was the revolutionary improvements in microcomputer technology in just the last few years that permitted such a fast, portable model to be constructed.

SECTION 1
GENERAL

1.1 PURPOSE OF THE FUNCTIONAL DESCRIPTION

The functional description (FD) for the Windows Integrated Logistics Assessment Model (WINLAM) is written to provide the following:

- System requirements that will serve as a basis for mutual understanding between the user and the developer.
- Information on performance requirements, preliminary design, and user impacts.
- A basis for the development of system tests.

This FD is organized according to the guidelines in DOD-STD-7935A, Military Standard, *DOD Automated Information Systems (AIS) Documentation Standards* (31 October 1988). Sections 2 and 4 are essential for understanding WINLAM and its interaction with the programming and budgeting process. Section 2 discusses background information on the requirements for WINLAM, improvements and impacts resulting from the development of WINLAM, and the present assumptions and constraints regarding WINLAM. Section 4 explains how WINLAM operates. It begins with a description of the general architecture and then describes each specific module, the logic of the computational processes, and the outputs generated.

1.2 PROJECT REFERENCES

The project sponsor for WINLAM is the Programs and Analysis Division, Directorate of Supply, Deputy Chief of Staff Logistics, Headquarters, United States Air Force (AF/LGSI).

The model uses budget and operational data related to the logistics and operations communities and develops a variety of information depending upon which module the analyst selects. The model is used by AF/LGSI to provide logistics and operational participants in the programming and budgeting process with rapid information to support decisionmaking.

Applicable project references are as follows:

AF/LEXI*/Synergy, Inc., *Tactical Logistics Assessment Model Functional Description.*

AF/LEXX*/Synergy, Inc., *Logistics Capability and Measurement System Spares Capability and Requirements*, 23 June 1989.

AF/PRP, *BPPBS Primer*, January 1989.

AF/XOXQW/Synergy, Inc., *PPBS Information Systems Requirements Analysis Functional Description*, 24 April 1989.

AF/XOXWF, *Air Force Planning Guide (U)*, 15 October 1989, Classified.

AFR 173-13, *US Air Force Cost and Planning Factors*, 28 January 1991.

AFR 400-3, *Weapon System Program Management*, 16 June 1989.

DOD-STD-2167A, *Military Standard, Defense System Software Development*, 26 February 1988.

DOD-STD-2168, *Military Standard, Defense System Software Quality Program*, 29 April 1988.

DOD-STD-7935A, *Military Standard, DoD Automated Information Systems (AIS) Documentation Standards*, 31 October 1988.

HOI 27-1, *DoD Programming System*, 30 May 1990.

HP 21-1, *Department of the Air Force Organization and Functions (Chartbook)*, 20 May 1988.

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* LEXI and LEXX are now known as LGSI.

1.3 TERMS

Air Force Planning Guide	A mid-term document developed by AF/XOXWF and designed to be used by planners throughout the Air Force as a source document for scenarios, threat information, objectives, capabilities, limiting factors, and assumptions data. It is for internal Air Force use only. It summarizes and documents the analysis performed by the Force Assessment System (FAS) following the closeout of the current Program Objective Memorandum (POM).
Defense Guidance	The Department of Defense (DOD) strategic plan for the development and employment of future forces. Provides the Secretary of Defense's threat assessment policy, strategy, force planning, resource planning, and fiscal guidance to all DOD organizations.
Force Structure	The number, types, and categories of aircraft, aircrew, and base operating support available for planning, programming, and budgeting. Includes basing and unit information.
Materiel Readiness	The level of weapon system end item availability in a mission capable (MC) condition. For aircraft, this term identifies the average MC rate. This function assumes that there are personnel available to man the aircraft. Materiel readiness is generally considered a subset of overall operational readiness.
MicroPOM	A microcomputer-based program written in Pascal and utilizing a dBASE database management system (DBMS). An Air Force standard system for exchanging programming information among Air Force organizations that are not equipped with a mainframe computer. This system is used by major commands (MAJCOMs) to develop and submit their POM to the Air Staff.
Operational Readiness	The measure of an organization's ability to perform its mission successfully. This function is a combination of materiel readiness, personnel readiness, and infrastructure support. In WINLAM, the infrastructure components (bases, facilities, and activities above wing level) are not specifically identified or constrained.

Personnel Readiness	The aircrew proficiency level based on a relationship between the average number of flying hours allocated to each aircrew each month (operating tempo [OPTEMPO]) and the aircrew performance ratings during annual check rides and exercises. This function assumes that aircraft are available to fly. Personnel readiness is generally considered a subset of overall operational readiness.
Scenario	A given timeline of events upon which an analysis of force structure is based. In FAS, scenarios are developed to be consistent with the Defense Guidance, Air Force intelligence estimates of enemy objectives, and significant planning assumptions.

1.4 OFFICES

AFCC	Air Force Cost Center
AF/LG	Deputy Chief of Staff, Logistics, Headquarters United States Air Force
AF/LGM	Director of Maintenance, AF/LG
AF/LGMM	Maintenance Policy Division, AF/LGM
AF/LGMY	Weapons Systems Division, AF/LGM
AF/LGS	Directorate of Supply, AF/LG
AF/LGSI	Programs and Analysis Division, AF/LGS
AF/LGSY	Aircraft and Missile Support Division, AF/LGS
AF/PE	Directorate of Programs and Evaluation
AF/XO	Deputy Chief of Staff for Plans and Operations, Headquarters United States Air Force
AF/XOO	Director of Operations, AF/XO
AF/XOOC	Contingencies Division, AF/XOO
AF/XOX	Director of Plans, AF/XO

SECTION 2

SYSTEM SUMMARY

2.1 BACKGROUND

During the past few years, the Air Staff has broadened the base of Force Assessment modeling to include logistics constraints. As a central part of this effort, a new family of fast parametric logistics models were developed for incorporation into the Air Force Wide Mission Area Analysis/Decision Support System (AFWMAA/DSS) housed in AF/XOOC. These models were designed to operate either in parallel with or interactively with the most important AFWMAA/DSS models.

2.1.1 LOGISTICS INPUT TO FORCE ASSESSMENTS

Initial developments yielded two successful sustainability models: the Tactical Systems Logistics Assessment Model (TLAM) for application in the Theater Warfare Model, and the Airlift Logistics Assessment Model (ALAM) for application in the Force Projection (FP) model. Within WINLAM, TLAM is denoted the Global Power Module (GPM) and ALAM the Global Reach Module (GRM). However, a complete picture of capability has traditionally called for a profile of both readiness (fitness of the force at the outset of war) and sustainability (effectiveness of the force in prosecuting a war). Each of these complementary aspects of capability contribute to an understanding of the overall impact of resource allocation decisions. During the early stages of sustainability modeling, it became apparent that the resource sets supporting sustainability-oriented models did not offer sufficiently broad program coverage to fully assess resource funding profiles such as program elements (PEs). The resource sets also needed to be broadened if they were to play a significant role in weapon system master planning. It became evident that effective logistics modeling would have to incorporate the fact that the bulk of weapon system funding requirements supports peacetime operating resources that are needed to maintain force readiness.

The Funding/Availability Multi-Method Allocator for Spares (FAMMAS) projects peacetime readiness for aircraft weapon systems based upon funding and requirements for depot-level reparables (DLR). FAMMAS operates in a single or multiple weapon system mode. The former allows the user to perform an assessment of one weapon system at a time, while the latter provides the capability of allocating funding across a selected set of weapon systems and estimating the availability of each as well as the combined availability. FAMMAS can be accessed in the single weapon system mode directly from WINLAM to generate reparable item funding/requirements and projected peacetime availability for the weapon system being assessed in WINLAM.

As development, testing and implementation proceeded, it became clear that these models offered the logistics community a potentially powerful tool to strengthen the hand of Air Staff logisticians who participate in the numerous Biennial Planning, Programming, and Budgeting System (BPPBS) exercises by quickly identifying the impacts of alternative positions and providing graphical documentation of those impacts.

To provide the user with software that is readily understandable and easy to operate, the program, formerly called the Integrated Logistics Assessment Model (ILAM), has been implemented on the Windows 3.1 operating system. The windows version provides the capability of rapid input combined with easily selectable graphical and textual output in a user-friendly environment. To reflect this change, the model designation has been changed to Windows Integrated Assessment Model.

Those who used the individual models realized that in order to reap the potential of these models it would be necessary to integrate them in a manner that would provide the analyst with both an automated database to service all models and a facility to quickly move between the models while saving and conveying data that support development of a complete picture of weapon system readiness and sustainability. WINLAM will satisfy these requirements.

2.1.2 BIENNIAL PLANNING, PROGRAMMING, AND BUDGETING SYSTEM (BPPBS)

The BPPBS process formalizes the methodology for developing, assessing, validating, and defending Air Force funding requirements. Although Air Staff reorganization has recently changed the location and function of primary BPPBS players, the BPPBS process is expected to continue in a similar exercise format. The process begins with the System Program Directors (SPDs) determining the level of logistics resources necessary to support their weapon systems. These requirements are sent to the Air Force Materiel Command (AFMC) as well as the appropriate major command that operates the weapon system for consolidation and verification before being presented to the Air Staff for funding. The Air Staff consolidates and prioritizes these requirements, balancing the various funding requests against fiscal limitations, and producing the Air Force Future-Year Defense Program (FYDP) for submission to the Office of the Secretary of Defense (OSD). OSD then submits the FYDP to the President, who in turn forwards it to Congress as the President's Budget (PB). This is a highly simplified version of the BPPBS process, and there are many iterations of the funding requests before the FYDP is finalized in the PB. Throughout the A1, A2, and A3 POM exercises, Air Force logisticians can be called on to provide information for and to participate in decisionmaking related to MAJCOM and Command in Chief (CINC) initiatives, buy-backs or resource swaps, and fiscal corrections. During this interactive process, the Air Force weapon system managers/monitors may be called on to determine capability

impacts for alternative fundings profiles. As these situations arise, WINLAM can be used to show how alternative program changes impact capability.

Because of its size and complexity, the Air Force has adopted standard formats for POM documentation and briefing. WINLAM has the capability to provide standard briefing slides and preformatted reports at the option of the user.

The weapon system management community described here consists of the Air Force Deputy Chief of Staff, Logistics AF/LG, Air Force Deputy Chief of Staff, Operations, the AFMC, and the SPDs. This community has a major forecasting responsibility. It must look 5 years into the future; understand the peacetime and wartime force structure requirements; document the peacetime and wartime logistics requirements to support that force structure; cost the logistics requirements; defend the request through the budgeting process; procure, store, and allocate the resources; and track all funding from appropriation to expenditure (to ensure maximum support per dollar). AFMC is always subject to oversight of its management of spares and the 2- to 5-year acquisition cycle required from placement of initial orders until new items appear in the system. Additionally, with an inconsistent budget, the force structure is in a constant state of flux. Because force structure determines logistics support requirements, a continually changing force structure, combined with an inconsistent (and independently developed) funding level, creates significant problems for the logisticians who must now obligate funds for spare parts for repair of aircraft 2 years from now. If the force structure expands too quickly, as in the early 1980s, procurement lead time for logistics support cannot keep up with the immediate demand for resources. If the force structure shrinks too quickly or is unstable, as in the late 1970s and early 1990s, the lead time requirements result in too much logistics support for aircraft being retired sooner than originally planned.

Although there are several mainframe computer systems within the weapon system management community to assist in defining logistics requirements, these large systems are encumbered by the substantial amount of data needed for detailed computations. Often the mainframe systems are unable to respond on short notice to Air Staff inquiries requiring analysis either because they are not easily accessible to the Air Staff or because they require intensive manual data entry. Moreover, many of these systems are Unclassified and as such cannot process the future force structure displayed in the FYDP and beyond. This severely limits logistics planners as they attempt to identify, isolate, and balance the shifts in funding, spare parts inventories, and force structure requirements.

WINLAM can improve this situation. Unlike the large models, the WINLAM model will be resident on a microcomputer at the Air Staff where it will be quickly accessible, and where BPPBS data developed before,

during, and after a budget exercise can be updated electronically in the model. When supported by near real-time recomputation of the operational impacts of funding changes on the weapon systems, weapon systems managers can respond with authority in time to influence major decisions. As a consequence, the logistics community should be able to provide a more responsive level of support to SPDs and AFMC.

2.1.3 AIR FORCE WEAPON SYSTEM PROGRAM ASSESSMENT REVIEW

In addition to participating with AFMC and the MAJCOMS in preparing POM and budget submission positions, each SPD is required to periodically brief the Air Force Council on the status of his weapon system program. The Weapon System Program Assessment Review (WSPAR) describes the health and well-being of a weapon system and presents requirements necessary to resolve any program shortfalls.

The WSPAR format traditionally has described the weapon system inventory, assessed peacetime and wartime capabilities, and identified required funding. The Sustainability Assessment Module (SAM) of the Weapon System Management Information System (WSMIS) has traditionally been employed to support requirements and their associated funding. The forecasting horizon of SAM is the current year and it can handle only a 30-day wartime assessment, although a 60-day assessment capability is being implemented. Thus, in the past, outyear requirements were not presented.

The current requirement is to assess and forecast weapon system mission capable rate, aircraft availability, the peacetime flying program, and combat capability 3 years beyond the current year. These assessments will continue to take into account subjective evaluations of impacts. However, preliminary tests have shown that GPM and GRM are highly effective in quantifying logistics impacts for outyears. In the future, new tools such as WINLAM can be employed to quantify these factors over the entire BPPBS planning horizon.

2.2 <u>WINLAM OBJECTIVES</u>

For WINLAM to be effective, it must produce timely, accurate, and analytically sound assessments of specific profiles of the force structure.

Therefore, WINLAM has the following objectives:

- Provide an interactive modeling capability that integrates readiness assessment with sustainability assessment.

- Maintain consistency in the treatment of data among the various force structure advocates at the Air Staff, MAJCOMs, and field organizations.

- Provide automated data exchanges, where possible, with programming, force assessment, and selected logistics data systems.

- Define the relationships between a variety of weapon system related resource funding and mission capable rates.

- Prepare timely, accurate, and analytically sound estimates of the impacts of funding changes on aircraft availability for weapon system advocates in the BPPBS process.

- Provide a rapid modeling capability with universal applicability.

- Provide a portable modeling capability that can be used in multiple geographical locations and that is self-contained in terms of data support.

2.3 EXISTING METHODS AND PROCEDURES

In general, AF/LG/XO rely heavily on MAJCOMs and CINCs to produce justification for weapon system adjustments and alternatives, and find that it is difficult to obtain timely assessments of proposed programmatic adjustments (Figure 2-1).

2.3.1 EXISTING LOGISTICS INPUT TO FORCE ASSESSMENTS

Capability analyses are normally performed on approved force structure values submitted after the BPPBS POM, Budget Estimate Submission (BES), and PB exercises. Because of the timing of these evaluations, any capability shortfalls are highlighted after the force structure approval process. Because of the nature of most mission areas, corrections of these shortfalls are implemented quickly with the promise that the funding will be provided at the beginning of the next budget exercise. If the correction has an impact on logistics, the adjustment in logistics funding to the program cannot be incorporated until the start of the next exercise.

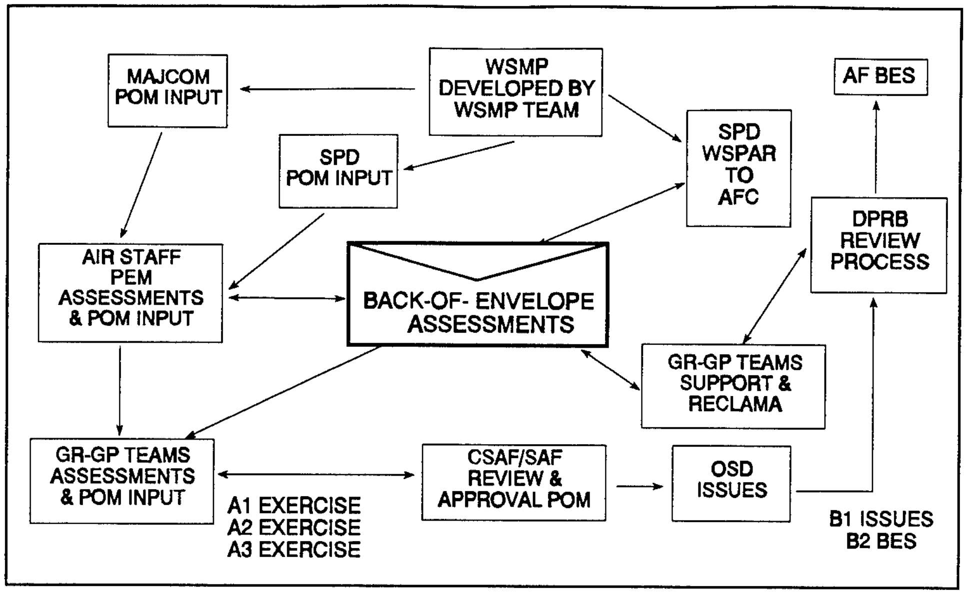

Figure 2-1. Existing Methods and Procedures

2.3.2 EXISTING BPPBS SUPPORT

Although AF/LG/XO are highly visible during the BPPBS process, their level of participation is sometimes limited by their staff's inability to respond with timely, in-depth analysis of funding alternatives within the fast-paced budget exercise process. The following generic actions take place during preparation of a typical POM. These steps are based on the pre-Air Staff reorganization position. Again, although the various committees, panels, and boards no longer exist, their functions can be expected to continue.

1. SPDs develop initiatives and inform AFMC.

2. CINC/MAJCOMs present initiatives to the Air Staff point of contact (POC) to improve mission capability.

3. The Air Staff POC validates and recosts the CINC/MAJCOM initiatives.

4. The Air Staff POC develops funding alternatives to the currently funded programs and the CINC/MAJCOM initiatives based on the current fiscal constraints.

5. The initiatives and alternatives are sent to other interested Air Staff offices for coordination with the comment that a lack of response by the deadline implies concurrence. The deadline may range from 3 hours to 1 day.

6. AF/LG/XO action officers attempt to determine the logistics impacts of the initiatives and alternatives while the CINC/MAJCOM prepares its analysis. Under most conditions, these analyses are not completed within the time limits.

7. The appropriate mission group (Global Reach-Global Power Teams) presents the CINC/MAJCOM initiatives and, if necessary, other funding alternatives to the Air Force Council (AFC) with or without *expressed* Air Staff coordination.

8. Several days after this presentation, the CINC/MAJCOM/XP or the CINC/MAJCOM commander addresses the AFC to present the CINC/MAJCOM position on the program adjustments.

9. The mission group receives new direction from the AFC to revisit/fund specific programs and to look for other ways to meet their funding constraints within a minimum amount of time.

This process does not allow enough time to cost each program alternative properly or in sufficient detail to establish operational or logistics impacts. A macro-level estimate is usually developed initially and refined after the exercise. As noted previously, any funding problems that occur are adjusted at the beginning of the next BPPBS exercise several months later.

2.4 PROPOSED METHODS AND PROCEDURES

WINLAM will provide a new analytical capability that will assist weapon system planners and programmers as they develop, advocate, and defend the Air Force structure position. The weapon system management community will be able to produce timely, accurate, and analytically sound justification for the requested funds. WINLAM differs from other models in that it projects both the peacetime capability to go to war (readiness) and the wartime capability of a weapon system to perform over a specified period of time (sustainability).

The following sections present procedures to perform the cost and capability assessments (Figure 2-2). The overall intent of these procedures is to allow Air Staff advocates to raise their profile in assessing alternative program adjustments. These actions require all levels (AF/AFMC) to consistently use current data for easy validation.

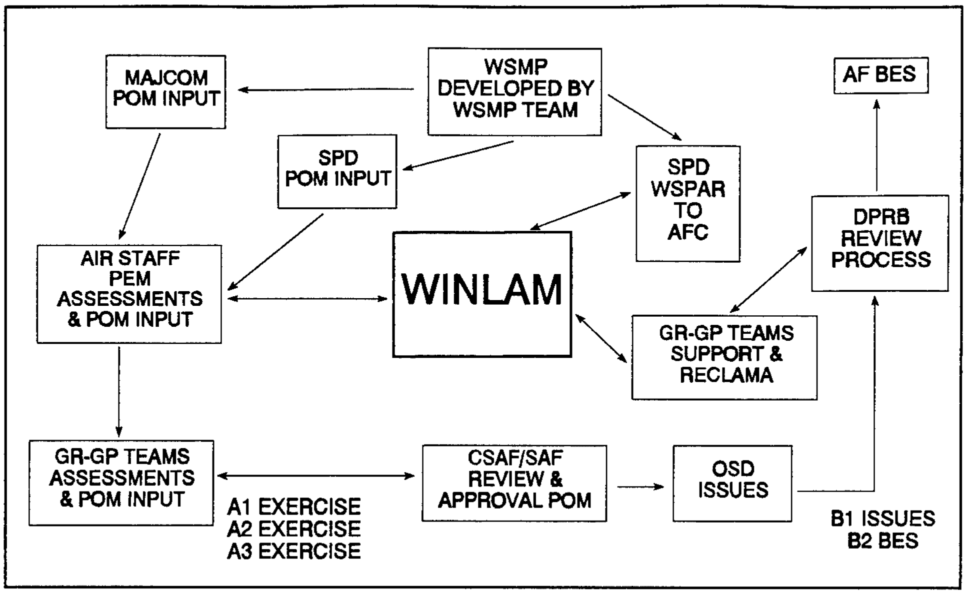

Figure 2-2. Proposed Interaction with WINLAM

2.4.1 PROPOSED LOGISTICS INPUT TO FORCE ASSESSMENTS

WINLAM is baselined at the end of the previous BPPBS exercise for each PE. This action is necessary to remain consistent with the information passed to the MAJCOMS and OSD. As force structure adjustments are proposed, WINLAM produces an estimate of the logistics impact on operational capability caused by the adjustment. Given the funding limits, what are the trade-offs between aircrew proficiency and aircraft availability? Given the current logistics resources, how long will it take to generate the remaining aircraft? Given the aircraft deployed in a combat theater, what sortie rates are available for the period of initial surge and subsequent sustainment in terms of current logistics funding for supply and maintenance?

2.4.2 PROPOSED BPPBS SUPPORT

Logistics impact estimates help eliminate those options that are unacceptable and highlight those options that warrant further investigation. If necessary, logistics-based alternatives can be developed independently for consideration. MAJCOMs and CINCs are advised of the WINLAM results so they can perform a more detailed analysis, if necessary. Assuming the potential for trade-offs, the AF/LG/XO action officer presents the WINLAM results to the other appropriate action offices for deliberation. Upon request, WINLAM will also produce additional alternatives for consideration.

Since WINLAM will provide analytically and operationally sound results, any recommendations to the BPPBS coordinating committees will have a higher probability of final acceptance without having to revisit the

alternatives later in the process. If revisits are necessary, WINLAM will continue to produce real-time evaluations of capabilities in support of the BPPBS process. The combination of WINLAM logistics assessments and FAS capability assessments will prepare the program element monitors (PEMs) to advocate analytically sound alternatives for funding consideration.

WINLAM provides an operationally oriented rationale for adjusting a funding profile in the required format for immediate presentation to the Air Staff. The development and evaluation of alternatives will be nearly instantaneous, with on-screen graphics suitable for large audience projection, automatic report generation for distribution, and electronic file creation for error-free data transfer.

During this process, the approved cost factors and program data are used to maintain data consistency among the various force structure advocates at the Air Staff, MAJCOMs, and field organizations. As necessary, alternative profiles can be passed to the FAS for operational validation.

SECTION 3
DETAILED CHARACTERISTICS

3.1 SPECIFIC PERFORMANCE REQUIREMENTS

This section describes specific performance requirements to be satisfied by WINLAM. These requirements include the accuracy of mathematical calculations, timing limitations, and storage capacities, which are all important to the efficiency and accuracy of WINLAM processing and model results.

3.1.1 ACCURACY AND VALIDITY

Numeric data entered into WINLAM will consist of both real and integer data. Real data may contain as many as eight significant digits plus the decimal point. Integer data may contain up to four significant digits. The programs must be able to read all numeric data and perform mathematical operations on the data with accuracy to the third decimal place on a scale of 0.000 to 1.000.

3.1.2 TIMING

The execution time for WINLAM must not exceed two hours because AF/LGSI and other Air Staff division-level analysts need to respond quickly to queries from Global Reach-Global Power (GR-GP) teams. When a GR-GP team is faced with an issue, it often needs to resolve the issue within a few hours. Therefore, after querying the appropriate offices, the team can only consider responses that are received within the allotted amount of time. AF/LGSI analysts must be able to makes changes to WINLAM data sets quickly and efficiently to run the model, review the outputs, and prepare information to be briefed.

3.1.3 CAPACITY LIMITS

3.1.3.1 Inputs

The basic input data for WINLAM are contained in Paradox tables. These tables are used to create weapon system-specific, binary WINLAM input data files, which are given 'aaf' extensions. These 'aaf' files, which can be edited within the WINLAM Data Management Module, are used directly by TLAM, ALAM, and the peacetime assessment models.

DMM files contain all of the data associated with a model run. Data are retrievable through an editing system in the DMM and are moved into random access memory (RAM) when the file is selected. Capacity is a function of the number of files stored and the capacity of the hard disk of the microcomputer system in use. More information on the FMS and the DMM can be found in Section 4 of this document.

3.1.3.2 Processing

WINLAM can be processed on an 80386 or 80486 microcomputer with 4 megabytes (MB) of RAM and a hard disk drive of 10 available MB or more. Windows 3.1 software is also necessary.

3.1.3.3 Outputs

Outputs generated during WINLAM's operation include all interactive screens and are almost too numerous to catalog. Each module of the model can present more than a hundred interactive screens and each screen can be considered an output. The more significant outputs are selected by the user through several menu-display options. Outputs include on-screen tables displaying static data from the WINLAM data set that can be viewed or edited. Therefore, virtually all input and computational data elements can also be considered output data elements as reflected in the following sections. On-screen tables also display data in various weapon system-related formats for viewing or editing, and can contain the model's computed results for comparisons with a baseline. Graphical and tabular screen representations from the model's dynamic graphing screens are also available. Both graphical and tabular output formats can also be printed to give the user hard copy products from which to analyze results. Another output option available for the user's convenience is the ability to save report information as American Standard Code for Information Interchange (ASCII) files. These output files can then be accessed by Harvard Graphics or other graphics packages to provide the user with more commonly used graphics in a standard briefing format.

3.2 FUNCTIONAL AREA SYSTEM FUNCTIONS

The functional environment in which WINLAM will provide support to the logistics analyst is described in Section 2.4. The functional nature of the system will be discussed in this section. A more extensive discussion of the model algorithms can be found in Sections 4.1 and 4.2.

3.3 INPUTS AND OUTPUTS

3.3.1 GPM INPUTS/OUTPUTS

3.3.1.1 GPM Inputs

GPM DATA ELEMENT	SOURCE
Number of Force Structure Records	WMP-3
Arrival Day	WMP-3
Departure Day	WMP-3
Number of Squadrons Deployed	WMP-3
Primary Aircraft Authorized (PAA)	AF/XOFP
Backup Aircraft Inventory (BAI)	AF/XOFP
Calibration Surge Sortie Rate (Sorties/AC/day)	WMP-5
Calibration Sustained Sortie Rate (Sorties/AC/day)	WMP-5
Current Peacetime Sortie Rate (Sorties/AC/day)	AF/XOF
Target Peacetime Sortie Rate (Sorties/AC/day)	AF/XOF
Average Wartime Sortie Flight Time (Hours)	WMP-5
Average Peacetime Sortie Flight Time (Hours)	AF/XOF
Wartime Maximum Turn Rate (Sorties/AC/day)	WMP-5
Peacetime Maximum Turn Rate	AF/XOF
Event Time Lines C day	User Specified
Event Time Lines D day	WMP-3
Massing Requirement (Aircraft per Mission)	ACC/AFE/PAC
Scheduled Sortie Rates	WMP-5/User Specified
Number of Time Periods in use for Attrition Rates	WMP-5
Attrition Rates	WMP-5
Current Peacetime Initial NMCM Rate	REMIS
Current Peacetime Initial TNMCS Rate	REMIS
Gross RSP Requirement Value in $ (millions)	AFMC/LGII
Annual RSD Buy Requirement in $ (millions)	UCD
Annual RSD Buy Funding in $ (millions)	UCD
Annual RSD Repair Requirement $ (millions)	UCD
Annual RSD Repair Funding $ (millions)	UCD

GPM DATA ELEMENT	SOURCE
Annual SSD Requirement $ (millions)	UCD
Annual SSD Funding $ (millions)	UCD
Annual OWRM Requirement in $ (millions)	AF/LGSY/AFMC
Annual OWRM Funding in $ (millions)	AF/LGSY/AFMC
Peacetime Availability Target (PAT) in Percent	AF/LGSY
Direct Support Objective (DSO), Period 1 (Number or Aircraft)	AF/LGSI
DSO, Period 2 (Number of Aircraft)	AF/LGSI
DSO Base Number of Aircraft	AF/LGSI
Order and Ship Time in Days	UMIPS/AFLCR51-4
Depot Repair Cycle Time in Days	UMIPS/AFLCR51-4
Sortie Service Time in Hours	User Specified
Current Year Manpower Percentage	AF/PER
Target Year Manpower Percentage	AF/PER
Current Year Equipment Percentage	AF/LGSP
Target Year Equipment Percentage	AF/LGSP
Current Year Maintenance Training Percentage	AF/LGMM
Target Year Maintenance Training Percentage	AF/LGMM
Number of Days to Run	WMP/User Specified

3.3.1.2 GPM OUTPUT DATA ELEMENTS (AIRCRAFT ACTIVITY SUMMARY)

Required Sorties (Number)

Maximum Sorties (Number)

Flown Sorties (Number)

Total Mission Capable Aircraft (Number)

Total PAA (Number)

Total TAI (Number)

Remaining Aircraft (Number)

Attrited Aircraft (Number)

Lost Sorties (Number)

Required Sortie Rate (Sorties/day)

Maximum Sortie Rate (Sorties/day)

Flown Sortie Rate (Sorties/day)

Average Sortie Rate (Sorties/day)

Cumulative Activity Ratio

Mission Capable Rate (% of aircraft available to fly missions)

Not Mission Capable Maintenance Rate in Percent

Total Not Mission Capable Supply Rate in Percent

Cumulative Required Sorties (Number)

Cumulative Flown Sorties (Number)

Cumulative Lost Sorties (Number)

Required Sorties Achieved (Percent)

Cumulative Required Sorties Achieved (Percent)

Maximum Turn Ratio

Average Sortie Flight Time (Hours)

Available Maintenance Hours (Hours per Day)

3.3.2 GRM INPUTS/OUTPUTS

3.3.2.1 GRM Input Data Elements

GRM INPUT DATA ELEMENT	SOURCE
Calibration Surge UTE Rate	WMP-5
Calibration Sustained UTE Rate	WMP-5
Current Peacetime UTE Rate	AF/XOF
Target Peacetime UTE Rate	AF/XOF
Scheduled UTE Rates	WMP-5/User Specified
Primary Aircraft Authorized (PAA) per Squadron	AF/XOFP
Total Aircraft Inventory (TAI) per Squadron	AF/XOFP
Backup Aircraft Inventory (BAI) per Squadron	AF/XOFP
AMC Reposition Number of Aircraft	AMC
AMC Reposition Day	AMC
Percentage Distribution by ALOC and Period	JSCAP Annex J
Block Speed by ALOC	AFP 76-2
Attrition Rate	WMP-5
Service Hours	AFP 76-2
On Load Hours	AFP 76-2
Off Load Hours	AFP 76-2

GRM INPUT DATA ELEMENT	SOURCE
Enroute Support Hours per Stop	AFP 76-2
Number of Enroute Stops	AF/XOFM
Number of Return Stops	AF/XOFM
Average Distances	AFP 76-2
True Air Speed	AFP 76-2
Allowable Cabin Load	AFP 76-2
Warning Time Days	User Specified
Order and Ship Time in Days	UMIPS/AFLCR51-4
Depot Repair Days	UMIPS/AFLCR51-4
Peacetime Availability Target (PAT)	AF/LGSI
Direct Support Objective (DSO)	AF/LGSI/WMP
Gross Readiness Spares Package (RSP) Requirement Value $ (millions)	AFMC/LGII
Annual RSD Buy Requirement $ (millions)	UCD
Annual RSD Buy Funded $ (millions)	UCD
Annual RSD Repair Requirement $ (millions)	UCD
Annual RSD Repair Funding $ (millions)	UCD
Annual SSD Requirement $ (millions)	UCD
Annual SSD Funding $ (millions)	UCD
Other War Readiness Materiel (OWRM) Funding Requirement $(millions)	AF/LGSY
OWRM Funding $ (millions)	AF/LGSY
Initial NMCM	REMIS
Initial TNMCS	REMIS
Current Maintenance Manpower Percentage	AF/PER
Target Year Maintenance Manpower Percentage	AF/PER
Current Maintenance Equipment Percentage	AF/LGSP
Target Year Maintenance Equipment Percentage	AF/LGSP
Current Maintenance Training Percentage	AF/LGMM
Target Year Maintenance Training Percentage	AF/LGMM
Average Number of Aircraft in Depot Maintenance during Peacetime	SPD
Average Days for Aircraft to Exit Depot Post Warning	SPD
Average Number of A/C Returned During First 50% of Depot Completion	SPD
Crew Ratio	SABLE/AMC
Crew Availability	AMC
Duty Day (hours)	AMC

GRM INPUT DATA ELEMENT	SOURCE
Rest Period (hours)	AMC
30 Day Limit (fly hour)	AMC
90 Day Limit (fly hour)	AMC
Unconstrained Period (days)	User Specified

3.3.2.2 GRM Output Data Elements

Mission Capable Rate

Not Mission Capable Rate

Not Mission Capable, Maintenance Rate

Not Mission Capable, Supply Rate

Maximum UTE Rate

Flown UTE Rate

Average UTE Rate

Double Average UTE Rate

Required UTE Rate

Total Hours Flown

Remaining Aircraft

Total Mission Capable Aircraft

Attrition Rate

Attrited Aircraft

Cumulative Attrited Aircraft

Ground Hours per Day

Ground Hours per Mission

Average Mission Flight Time

Average Mission Cycle Time

Total Missions Flown

Cumulative Aircraft Lost

Average Missions per Day

Available Maintenance Hours per Flying Hour

Million Ton-miles per Day

Tons Delievered per Day

Cumulative Tons Delivered

Cumulative Depot Returns

GRM OUTPUT

Crew Constrained UTE Rate

Cumulative Activity Ratio

Theoretical Max UTE Rate

3.4 FAILURE CONTINGENCIES

There are no built-in features in WINLAM that account for machine failures, power losses, or other problems. In preparation for failures of any kind, the user should maintain a working copy of the model and the most recent database on floppy diskettes or a cassette tape cartridge if possible. The user should also know of an alternate machine with a compatible environment for WINLAM processing in case of machine failure, damage, or loss.

SECTION 4
DESIGN CONSIDERATIONS

4.1 SYSTEM DESCRIPTION

With the concepts of resource trade-offs in peacetime readiness and materiel consumption during wartime operations as its bases, WINLAM creates a unique framework for analysis, using data and computational procedures that are well established and accepted in the Air Force. The model draws on evolutionary improvements in cost analysis and availability modeling. It builds on this foundation using techniques of interactive data display and manipulation which rely on advanced concepts of information processing for microcomputers. The WINLAM provides a fresh, new look at resource relationships in a manner that will permit their rapid application to analysis in support of the programming and budgeting process.

From a technical viewpoint, the WINLAM can best be described as a system of interrelated models using dynamic, interactive displays that are grounded in cost models and parametric equations. The model is characterized by a unity of concept and design that users will quickly come to appreciate. Operational capability is initially designed into an aircraft and then supported with an expensive array of ground-based resources which are in every sense a part of the weapon system's capability. Spare parts and the repair skills to install them are a central part of the weapon system's capability package because they determine availability of the aircraft for a mission. Unfortunately, the recurring nature of a weapon system's supply and maintenance costs make them vulnerable to budget cuts as other weapon systems and programs compete for limited defense resources. There is, therefore, a continuous need to justify and balance expenditures which sustain operational capability.

From a weapon system viewpoint, operational capability is expressed in terms of readiness and sustainability. Readiness is defined as the weapon system's availability, maintained in peacetime, that can be drawn upon at the commencement of hostilities. Sustainability is defined as the continuing availability level that can be supported during the conflict given the expected OPTEMPO.

Weapon system availability is defined as the proportion of total time during which the average aircraft is not down for lack of parts (not mission capable, supply) or down for maintenance (not mission capable, maintenance). It can also be described as the proportion of the total number of aircraft available for a mission at a given time.

The mission capable (MC) rate is equal to one minus the not mission capable (NMC) rate, which can be expressed in terms of two components, total not mission capable, supply (TNMCS) and not mission capable, maintenance (NMCM). The former includes aircraft that are simultaneously down for both supply and maintenance, while the latter includes aircraft down only for maintenance. Further discussion of the components of the NMC rate is given in Appendix B.

Commanders typically add another dimension to readiness. A complete look at the readiness of combat forces demands also that the people who operate and maintain weapon systems function at peak effectiveness — and that means peacetime training. Personnel readiness demands expenditure of resources while equipment readiness seeks to preserve stocks of resources at some target level. Most readiness assessment models look at one side of this relationship, seldom giving both perspectives simultaneously. The WINLAM treats both perspectives and assists planners in balancing this delicate equation.

Peace and war are contiguous on a time line. One day we are at peace, the next day we may be at war. Therefore, the ability to sustain combat operations is dependent on the same resources (and state of readiness) that existed the day before war began. While modeling the ability of a force to sustain wartime operation is different from modeling readiness issues, the resource base should be the same and initial peacetime readiness defines the outcomes of the early days of combat.

The WINLAM was developed as a microcomputer-based model to help the Air Staff, MAJCOMS, the SPDs, and other interested agencies to address resource issues related to both readiness and sustainability. While their internal logic differs, the WINLAM modules are compatible and together they provide a standard system which describes aircraft availability rates for readiness and sustainability in terms of support provided by various resources and resource levels.

The configuration of the WINLAM and development of WINLAM data sets will be managed by AF/LGSI. WINLAM software as well as a WINLAM data set will be provided to MAJCOMs and other agencies to run on their own microcomputers in any secure area.

4.1.1 WINLAM Assessment Modules

There are three WINLAM assessment modules available to the planner/budget programmer/analyst (Figure 4-1). These conform to the readiness and sustainability dimensions of analysis discussed above. The WINLAM Force Readiness Module (FRM) determines peacetime availability (readiness) based on a broad set of resources. The WINLAM GPM determines wartime availability (sustainability) for combat weapon systems given

considerations of deployment to various theaters, sortie rates, and attrition. GPM is more commonly known as TLAM. The WINLAM GRM establishes supportable utilization rates for committed airlift aircraft (sustainability) using much the same logic as the GPM, but with some distinct differences. GPM is generally referred to as ALAM.

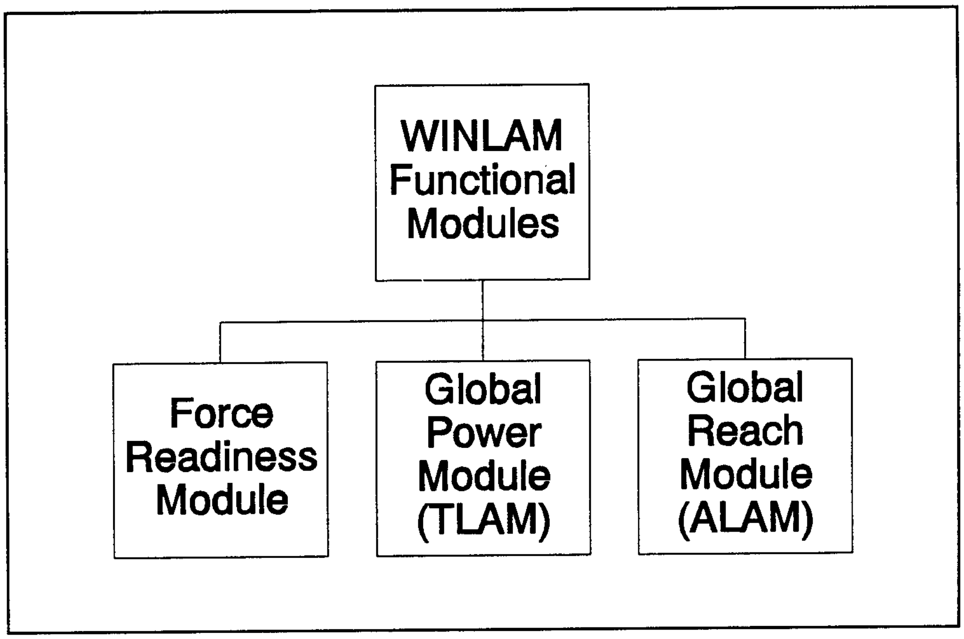

Figure 4-1. WINLAM Assessment Modules

4.1.1.1 WINLAM Force Readiness Module

The FRM in effect consists of two distinct models, as depicted in Figure 4-2. The Materiel Readiness Model is a FAMMAS model operating in a single weapon system mode. It develops estimates of peacetime aircraft TNMCS rates based upon past and projected funding/requirements for spares (RSD) buy and repair activities and consumable (SSD) buys. The NMCM rates are estimated by the user. The resulting MC rates are utilized as starting points in the wartime assessment models, TLAM and ALAM, as well as providing information for peacetime weapon system assessments.

To provide information on peacetime sortie generation capability, the Peacetime Operational Status Model (POSM) is included in WINLAM. This model generates the Peacetime Reports, which summarize peacetime MC rates, flying hours, and sorties for each weapon system.

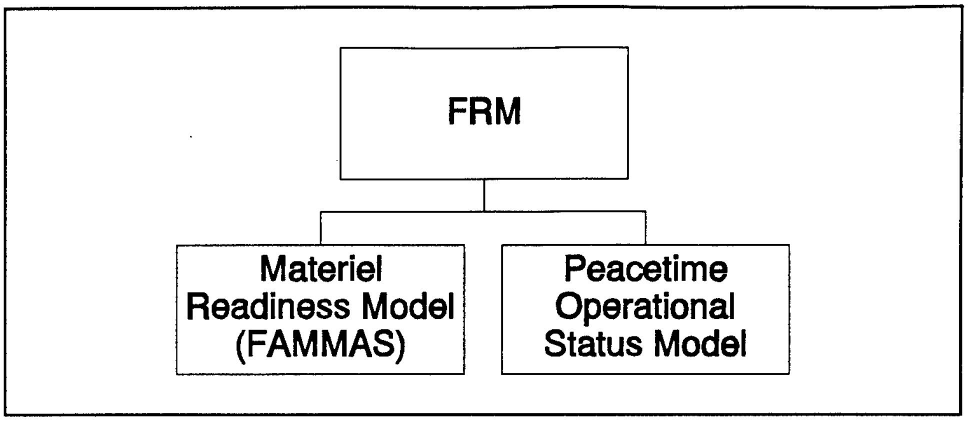

Figure 4-2. Force Readiness Module

4.1.1.2 WINLAM Global Power Module (TLAM)

TLAM is the WINLAM's assessment module that addresses tactical aircraft sustainability in wartime. It does so by relating funding levels for specific types of supply and maintenance support to an aircraft availability rate that includes considerations of deployment and attrition. TLAM operates with a database that is compatible with the FRM. The essential difference lies in an assumption that wartime sortie rates will be considerably higher than peacetime rates on a daily basis. Also, FRM addresses average availability levels over long periods of time, while TLAM looks at daily availability of aircraft as they fly wartime sorties.

The functional components of TLAM are shown in Figure 4-3. The module contains both a supply function and a maintenance function. The user enters required daily sortie rate information through a series of war planning files. Resource information is taken from the program/budget files. The model attempts to fly the required sortie rate each day and "consumes" resources. Remaining resource levels at the end of each day determine the number of available aircraft projected for the next day, i.e., the aircraft *not* inoperable for supply shortages or maintenance. A "recovery" function allows the replenishment of additional spare parts throughout the duration of the combat scenario, based on planned resupply. The mechanisms used by TLAM to perform these operations are parametric equations. TLAM is a parametric model whereby proxy or indirect variables are used to explain or predict the behavior of other variables. The underlying parametric functions in TLAM have been validated.

The supply function describes availability as percentage of time not down for parts. The function addresses inventories which include separate categories for peacetime stocks of spares, war reserve spares, and other categories including depot or contractor regeneration of exchangeable spares, aircraft, and engines.

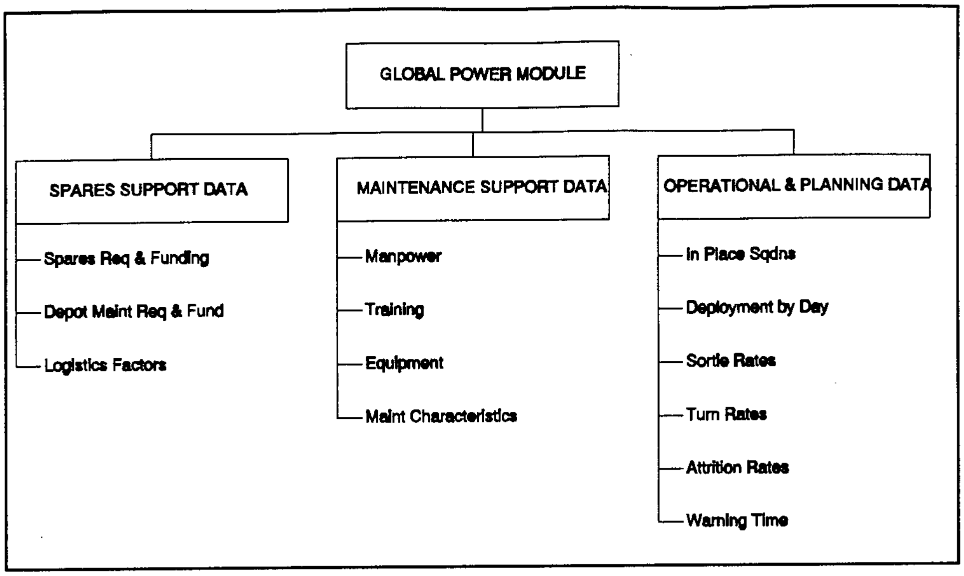

Figure 4-3. Global Power Module (TLAM) Functional Architecture

The maintenance function is used to model aircraft availability as percentage of time not down for maintenance. This is done by factoring into the function the influence of current maintenance manpower, training level of direct maintenance personnel, and maintenance equipment on hand. Inherent maintainability of the weapon system is also considered.

Munitions and fuel are not included in this version to TLAM. Aircrew availability is also not addressed by the model. While munitions, fuels, and aircrews are important considerations in determining sortie generation rates, the model only estimates aircraft generation, e.g., sortie availability rates and the number of available aircraft. This distinction, while important to understand, does not in any way diminish the value of the model with regard to the assessment of the supply and maintenance functions. It does suggest that further work incorporating munitions, fuels, and aircrews would greatly enhance the model's authority.

To use the TLAM module the analyst first selects a specific database by weapon system and fiscal year using the Data Management Module. Each file provides all associated logistics and operational data necessary to calibrate the major parametric functions. When transitioning to the analysis module, the model first uses all current file data values to calibrate the run-time parametric equations. Additionally, a selection of run-time options can be set just before running as desired by the user (number of days to run, comparison mode, etc.) The sequence and nature of processing steps is discussed in Section 4.2.

4.1.1.3 WINLAM Global Reach Module (ALAM)

ALAM is the airlift counterpart to TLAM. The functional architecture for the model is illustrated in Figure 4-4, and its close relationship to TLAM can be readily seen. Since airlift aircraft utilization (UTE) rates are a function of funding for many resource programs, ALAM provides a single integrated structure for estimating the impact of funding changes in most of these programs. Like TLAM, initial ALAM development focused on the same supply and maintenance support programs that affect aircraft generation.

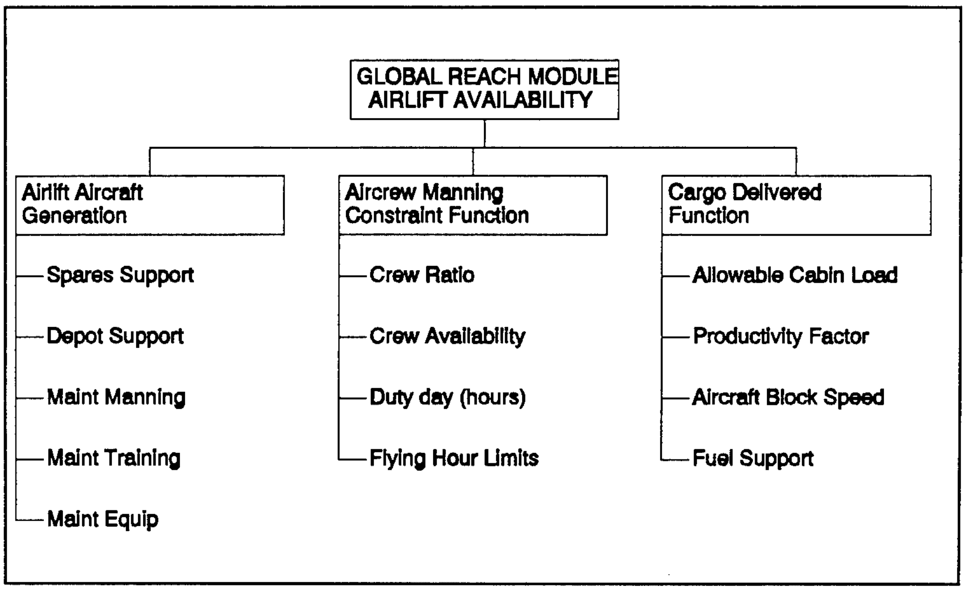

Figure 4-4. Global Reach Module (ALAM) Functional Architecture

Critical programs for supply support include replenishment spares (both peacetime and wartime stocks) and depot-level maintenance for maintaining spares, aircraft, and engines in serviceable condition.

The maintenance function currently considers maintenance manning, training levels, and funding for maintenance equipment. These programs are critical if Air Mobility Command (AMC) is to maintain the high UTE rates required for wartime support; any significant reduction or underfunding of these programs would seriously degrade capability. Broad-based parametric estimators have been included in the model for each of these resource areas.

ALAM departs from the logic of TLAM with the introduction of aircrew modeling. Because of the clear interrelationship between aircraft generation and aircrew generation, aircrew manning is incorporated into the analytical framework of ALAM. Several aircrew factors influence the ability to maintain UTE rates and crew

ratios. Factors such as qualified crew members, flying hour limits, and staging impacts at enroute locations have a substantial effect on aircrew ratios and UTE rate levels that can be met.

ALAM can be described as a series of static and dynamic analytical processes that combine to provide UTE rate information. As in TLAM, the static routines provide the calibration of a series of parametric variables that are then used in the form of parametric equations in the dynamic (day-to-day) routines.

The inputs for the static routines that define the values of specific parametric variables are related to specific independent resource funding levels for logistics programs. If funding changes are considered, the static routines provide rapid recomputation of these variables for the dynamic portion of ALAM.

When a weapon system database is selected, all parametric variables are computed and made available to the dynamic routines, which can be run for any set of required UTE rates for any period of time up to 180 days. Section 4.2 describes the model and sequential processing steps.

4.1.2 SYSTEM ARCHITECTURE

In addition to the three functional system modules described above, there is a data management service function that supports the WINLAM: the Data Management Module (DMM). From an information processing perspective, the four WINLAM modules describe the WINLAM's information system architecture (Figure 4-5).

Within WINLAM, the DMM operates as a logical entity. Principal functions performed by the DMM are shown in Figure 4-6 and include selecting weapon system records at an appropriate level of aggregation (both original records and records previously modified for analysis), viewing and editing factor and cost data associated with weapon system records, comparing data records, displaying and printing records, deleting records, saving, and printing records.

The file options, shown in Figure 4-7, are standard file functions — open, save, save as (save under another name), and delete. A new file can be created from an existing Paradox data set by selecting one of the sets shown on the New screen. Finally, the assessment year can be selected. Data are saved in a binary format as *.aaf files.

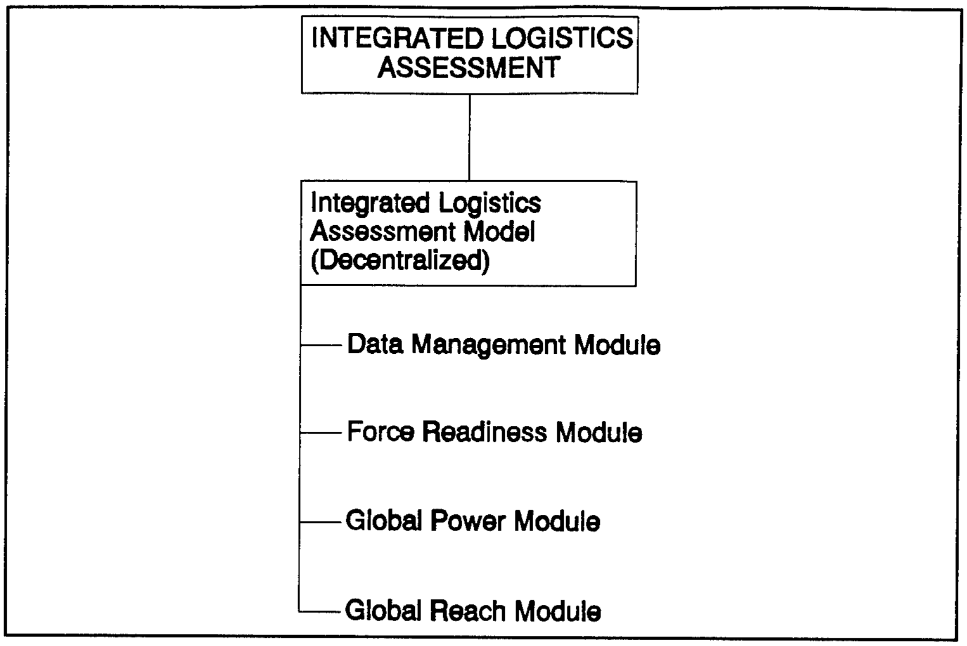

Figure 4-5. WINLAM System Architecture

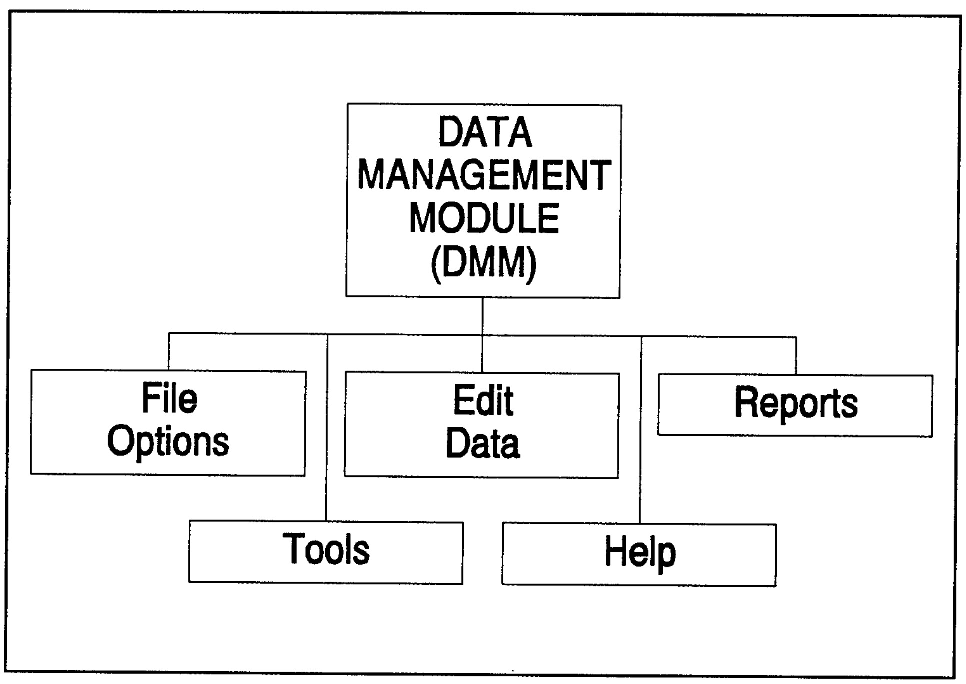

Figure 4-6. Data Management Module Functions

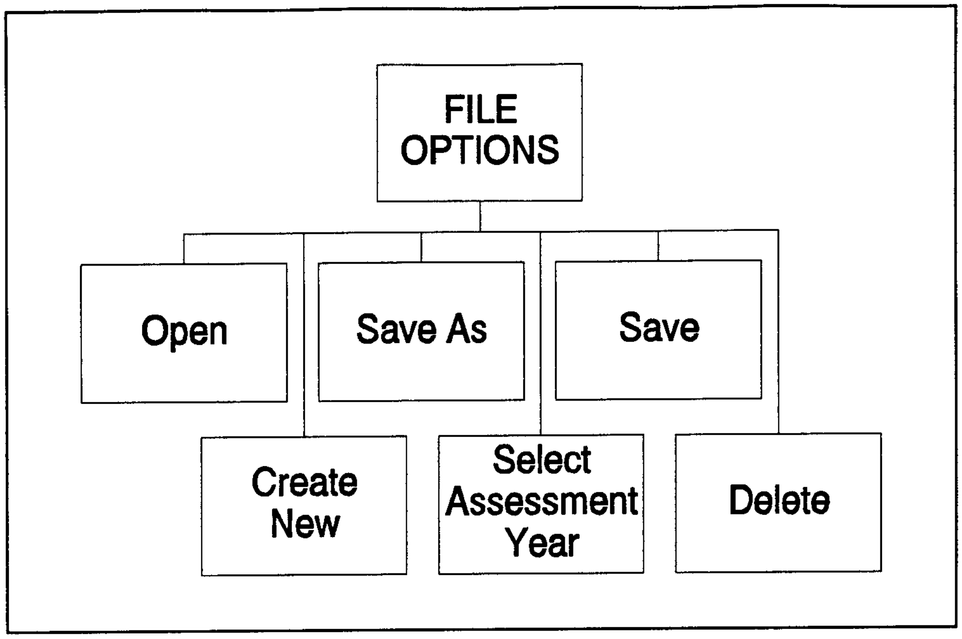

Figure 4-7. DMM — File Options

Figure 4-8 presents the edit options. The data categories displayed represent the Standard editing screen. Two other options are available: Advanced and System Administration. The Advanced edit selections include a variety of funding and personnel parameters, which do not normally require modification for a model run. The System Administration selections, which are password restricted, include USAF policy parameters and system constants. The former include model parameters such as the direct support objective, WMP objective surge and sustained rates, etc. The latter include constants that calibrate the model to historical data, developed during the validation process.

The WINLAM report generation options, depicted in Figure 4-9, include the following:

- FAMMAS — peacetime availability assessment
- Peacetime operational status — aircraft availability and sortie generation capability
- Global Power Model (TLAM) — wartime sortie generation capability for nonairlift aircraft
- Global Reach Model (ALAM) — wartime flying hour generation capability for airlift aircraft
- Input data echo — report listing input values for the selected data set

The appropriate wartime model used is based on the MD for the selected data set.

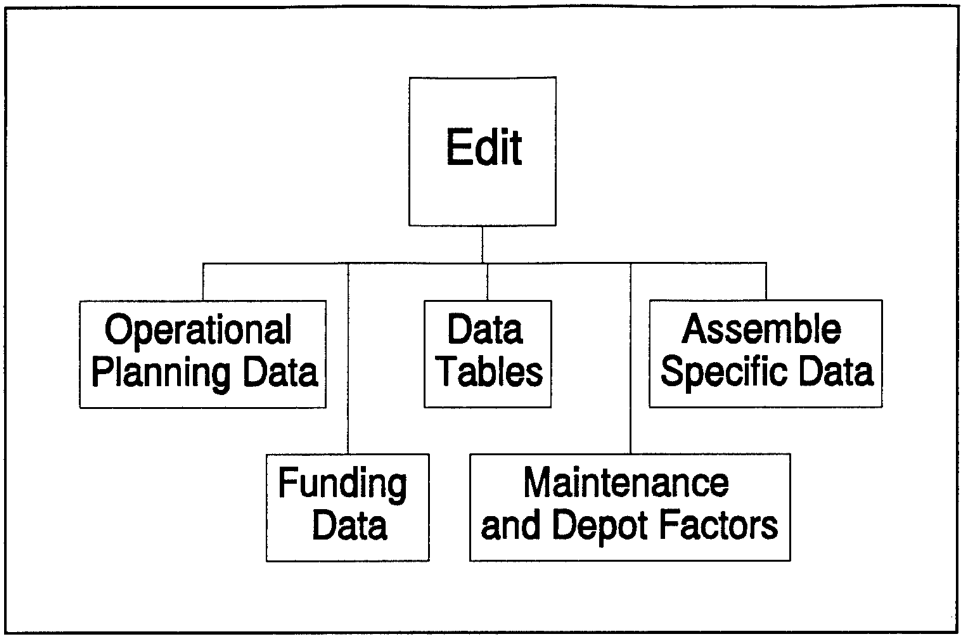

Figure 4-8. Edit Options, Standard User Level

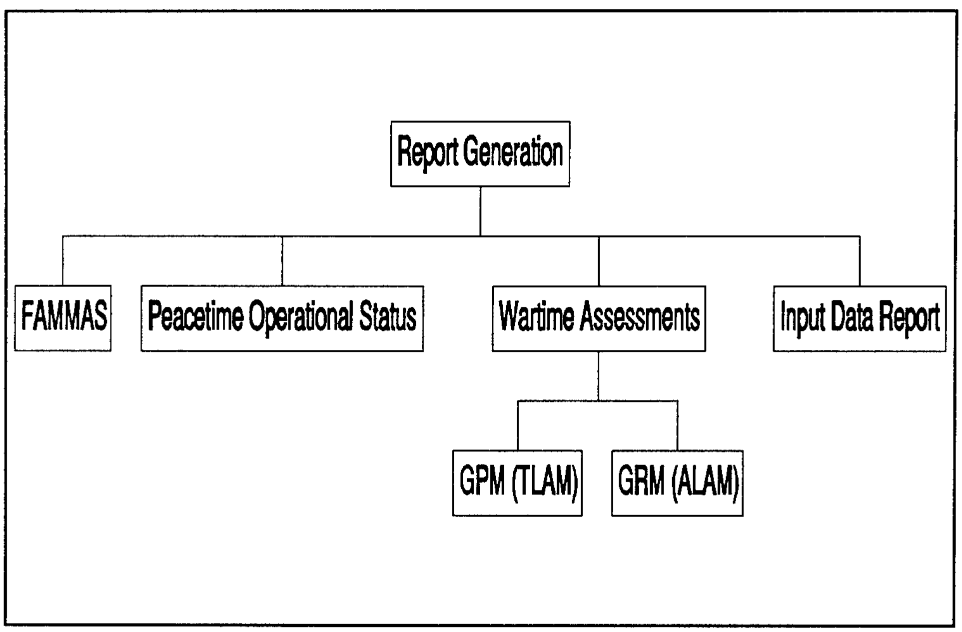

Figure 4-9. WINLAM Report Generation

Tools available to the user, outlined in Figure 4-10, include setting the user level, setting the classification, and displaying file information. The three user levels, Standard, Advanced, and System Administration, are discussed above. The selected classification appears on the screen and all generated tabular and graphical output.

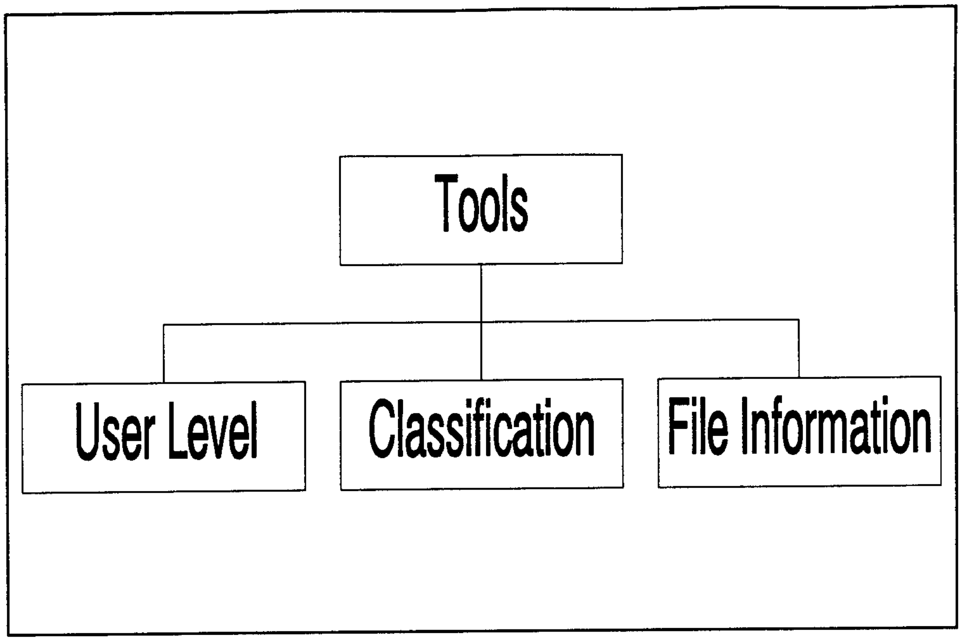

Figure 4-10. Tools Options

4.2 SYSTEM FUNCTIONS

This section presents the methodology for the analytic models utilized by WINLAM. Equations are presented for the primary model functions. All of the models are written in the C or C++ programming languages, and all are implemented in the Windows environment. The variable names used in this section generally correspond to the program names. In some cases, for purposes of clarity in presenting the equations, shortened designations are used (e.g., C_1 for C1Fct). Indices for day, theater, force records, etc., may differ from the program designations in some cases to more clearly identify the indexed parameter.

4.2.1 FORCE READINESS MODULE SYSTEM FUNCTIONS

4.2.1.1 Peacetime Operational Status Model

The Peacetime Operational Status Model generates the Peacetime Report utilized in the WSPAR process. MC rates, obtained from FAMMAS, are used along with baseline weapon system parameters such as the MC goal, PAA, possessed aircraft, annual required flying hours, annual required sorties (for non-airlift aircraft). Projected maximum achievable flying hours and sorties are estimated for non-airlift aircraft by the following algorithms:

$$MaxSorties = MC \times PossdAcft \times StandardTurn \times FlyDaysPerMo \times 12 \qquad \text{[Eq 4-1]}$$

$$MaxHours = MaxSorties \times ASD \qquad \text{[Eq 4-2]}$$

where

MC	= estimated mission capable rate for the analysis year
PossdAcft	= possessed aircraft
StandardTurn	= standard peacetime turn rate
FlyDaysPerMo	= average number of flying days per month = 20.78
ASD	= average sortie duration

For airlift aircraft, the maximum flying hours are computed by:

$$MaxHours = MC \ x \ PossdAcft \ x \ StandardUTE \ x \ FlyDaysPerMo \ x \ 12 \qquad \text{[Eq 4-3]}$$

where

StandardUTE = standard maximum UTE rate (flying hours per aircraft per day)

4.2.1.2 Minimum MC Rate Computation

4.2.1.2.1 Peacetime MC Rate

Two minimum mission capable rates are generated within WINLAM, a peacetime rate and a wartime rate. The peacetime rate is based upon training requirements with provision for scrubbing of missions due to maintenance or operational problems.

4.2.1.2.1.1 Strategic Airlift Aircraft

The minimum MC for airlift is determined by accounting for training missions, operations missions, alert aircraft, maintenance training, and attrition. The number of aircraft required for training missions to schedule (TMTS) (missions necessary to meet the training requirements), accounting for operational no-gos (nonmaintenance attrition), is given by:

$$TMTSAcft = \frac{PAA \times TrngFctr}{1 - NonMXAttrFctr} \qquad \text{[Eq 4-4]}$$

where

PAA = primary aircraft authorized

TrngFctr = training factor

NonMxAttrFctr = nonmaintenance attrition factor

The number of aircraft for operations missions to schedule (OMTS) per day to meet requirements, accounting for nonmaintenance attrition, is:

$$OMTSAcft = \frac{PAA \times OpnsTrngFctr}{1 - NonMXAttrFctr} \qquad \text{[Eq 4-5]}$$

where

OpnsTrngFctr = operations training factor

The number of alert aircraft required per day, AARAcft, is:

$$AARAcft = PAA \times AlertFctr \qquad \text{[Eq 4-6]}$$

where

AlertFctr = alert factor

Additional spare aircraft to account for attrition due to maintenance, MxAttrAcft, are given by:

$$MxAttrAcft = TMTSAcft \times MxAttrFctr \qquad \text{[Eq 4-7]}$$

where

MxAttrFctr = maintenance attrition factor

Finally, the number of aircraft required for maintenance training is given by:

$$MxTrngAcft = PAA \times MxTrngFctr \qquad \text{[Eq 4-8]}$$

where

MxTrngFctr = maintenance training factor

The total minimum number of aircraft required to be mission capable is:

$$MinMCAcft = TMTSAcft + OMTSAcft + AARAcft + MxAttrAcft + MxTrngAcft \qquad \text{[Eq 4-9]}$$

The minimum required MC rate is computed by:

$$MinMC = \frac{MinMCAcft}{PAA} \qquad \text{[Eq 4-10]}$$

Note that when all equations are combined into the MinMC computation, PAI cancels out. Therefore it is not included in the implementation of the model. The parameter is included in this discussion only to enhance clarity.

4.2.1.2.1.2 Tactical Aircraft

The minimum MC computations for fighters and other tactical aircraft are based on required daily sorties. The required daily squadron sortie rate, SR, is given by:

$$SR = \frac{UTERate \times PAA}{FlyDaysPerMo} \qquad \text{[Eq 4-11]}$$

where

UTERate = required sorties per aircraft per month

FlyDaysPerMo = average number of flying days per aircraft per month

The sorties to schedule (STS) per day to meet the required sortie rate, accounting for nonmaintenance attrition, is:

$$STS = \frac{SR}{1 - NonMxAttrFctr} \qquad \text{[Eq 4-12]}$$

where

NonMxAttrFctr = nonmaintenance attrition factor

Two sorties per aircraft per day are assumed. The number of jets to schedule (JTS) for a single go, accounting for attrition from the morning flights, is:

$$JTS = \frac{STS}{2} \times (1 + BreakRate) \qquad \text{[Eq 4-13]}$$

where

BreakRate = break rate per sortie

The final number of aircraft to schedule, including maintenance attrition, is computed by adding the maintenance attrition factor to JTS. If the attrition factor is less than 1, then 1 aircraft is added to JTS. The result is truncated to an integer value.

$$TotJTS = Trunc(JTS + \max(1, MxAttrFctr)) \qquad \text{[Eq 4-14]}$$

where

Trunc(x) = truncated to the integer value of x

MxAttrFctr = factor accounting for attrition due to maintenance

The minimum number of MC aircraft is then given by adding the maintenance training aircraft.

$$MinMCAcft = TotJTS + MxTrngFctr \times PAA \qquad \text{[Eq 4-15]}$$

where

MxTrngFctr = factor accounting for aircraft needed for mainenance training.

Finally, the minimum MC rate is given by:

$$MinMC = \frac{MinMCAcft}{PAA} \qquad \text{[Eq 4-16]}$$

The productivity factor, defined as the ratio of the sorties to schedule per day per aircraft, is also computed and displayed.

$$ProdFct = \frac{STS}{MinMCAcft} \qquad \text{[Eq 4-17]}$$

4.2.1.2.2 Wartime MC Rate

The minimum MC rate for wartime is defined in terms of the minimum peacetime MC rate that results in no loss of sorties/flying hours relative to those scheduled over a 90-day combat period. To estimate this variable, WINLAM iterates through the Tactical Systems Assessment Model (TLAM) or the Airlift Systems Assessment Model (ALAM), beginning with initial values of peacetime NMCM/TNMCS rates and increasing them by a user-defined increment until at least one sortie/flying hour is lost. The minimum MC rate is defined as the last MC rate before losing sorties. The user can specify whether the TNMCS, NMCM, or both are incremented during the iteration process. If both are incremented, the user specifies the ratio between them. For example, with a ratio of 0.25, for every 1 percent increase in TNMCS, NMCM increases by 0.25 percent. The computation is performed for each year from the user-specified base year on. The base year generally represents the first year to be assessed in TLAM/ALAM. All funding values are temporarily set equal to the corresponding requirements for this computation. The outputs are the minimum MC rate with the corresponding NMCM and TNMCS rates.

4.2.1.3 Materiel Readiness Model (FAMMAS)

The WINLAM Materiel Readiness Model is an adaptation of the FAMMAS. Various versions of the model have been used by the Air Force over the past several years for allocating spares funding across weapons systems and estimating the effects of funding shortfalls on weapon system peacetime availability. The current version is implemented in Windows and can be called by the WINLAM executive program. This version addresses a single weapon system at a time and does not allocate funding among weapon systems, as does the stand-alone version.

Over the past 3 years, numerous changes in the management of Air Force reparable items rendered the original FAMMAS architecture nearly obsolete. Depot-level reparable (DLR) items are now procured and repaired with funds made available through the Reparable Stock Division (RSD) of the Stock Fund with more flexibility but less visibility over the distribution of future funding between procurement and repair. (BP15 has all but disappeared.) Dollars available are now limited by OSD-controlled Obligation Authority (OA) rather than by appropriation. Stock Fund dollars are generated by customer demands and paid for with O&M funds that also pay for many commodities and services other than reparable spares. The availability of customer dollars is further constrained by policies such as unit cost target ratios issued by OSD. While fundamental relationships between future levels of serviceable inventory and weapon system readiness have not changed, the projection of those levels (as a function of funding) must now be accomplished using different data and data sources and should incorporate the impact of unit cost target policies.

To accommodate these changes, FAMMAS has evolved from a spreadsheet structure to the current C++-based program, with significant modifications to the underlying model.

4.2.1.3.1 Input Data

4.2.1.3.1.1 DLR Funding Data

For each weapon system, both required and allocated funding data are needed for each of the 8 years noted below. Repair and procurement funding data for replenishment spares are used, and procurement funding for initial spares is included. These funding data are expressed in terms of AFMC Obligation Authority (OA) within the RSD of the USAF Stock Fund. Additionally, System Support Division (SSD) funding data are included as an input. The source of these funding data is the Unit Cost Document, generated by AFMC/FM.

Table 4-1 illustrates the input data for buy and repair OA requirements and funding over an 8-year window for one weapon system. Initial spares and SSD funding and requirements are included as illustrated. This table illustrates the past 4 years, current year, and 3 future funding years.

Table 4-1. DLR Funding Input Data

```
FAMMAS v1.03d OUTPUT
CLASSIFICATION    : UNCLASSIFIED
DATE              : Oct 15, 1993
DATA DESCRIPTION  : 93-94 PB
WEAPON SYSTEM     : F-15

 DLR Funding Summary (Stand Alone)
```

F-15	1989	1990	1991	1992	1993	1994	1995	1996
BUY RQMT	165.4	113.4	213.5	140.8	181.3	193.4	197.8	202.4
BUY FUNDING	150.8	83.5	139.4	68.4	29.1	18.9	19.4	19.8
PERCENT	91.2%	73.6%	65.3%	48.6%	16.1%	9.8%	9.8%	9.8%
INIT SP RQMT	0.0	0.0	0.0	0.0	0.0	36.3	37.1	38.0
INIT SP FUNDING	0.0	0.0	0.0	0.0	0.0	36.3	37.1	38.0
PERCENT	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%
SSD RQMT	11.9	10.7	8.8	9.2	8.8	9.7	9.9	10.1
SSD FUNDING	10.5	9.7	8.8	9.2	8.8	9.7	9.9	10.1
PERCENT	88.2%	90.3%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
REPAIR RQMT	111.9	107.2	87.9	92.1	88.3	96.9	99.2	101.4
REPAIR FUNDING	104.5	96.6	87.9	92.1	88.3	80.0	99.2	101.4
PERCENT	93.4%	90.1%	100.0%	100.0%	100.0%	82.5%	100.0%	100.0%
TOTAL RQMT	277.3	220.6	301.4	233.0	269.6	326.6	334.1	341.8
TOTAL FUNDING	255.3	180.1	227.3	160.5	117.4	135.2	155.6	159.2
PERCENT	92.1%	81.6%	75.4%	68.9%	43.6%	41.4%	46.6%	46.6%
EXPECTED AVAIL				0.895	0.885	0.768	0.671	0.625

In the later discussions, terminology used is defined as follows:

- *Base Year.* The year immediately preceding the current year. This year is used for calibration of functions in the model. In the examples shown in this section, the base year is 1992.

- *Allocation Year.* A future year that the analyst has selected to work with (i.e., if he or she is reallocating or developing recommended spreads for 1994, that is the current allocation year).

- *Assessment Year.* When in the multiple weapon system mode, as funding levels are changed, the model looks one year into the future and determines how funding should be spread. If the allocation year is 1994, the assessment year is 1995. (However, changing the allocation in one year will alter weapon system availability for several years beyond.)

4.2.1.3.1.2 Inflation and Carryover Factors

The model carries over a proportion of unfunded procurement, repair, and SSD requirements. Carryover factors, which can vary among weapons systems, are policy variables that can be modified. The default values used are 0.25 for each, meaning that 25 percent of unfunded requirements in a specific year will remain as a legitimate requirement for the next year and will be added to that year's stand-alone requirement. Inflation factors, as approved by OSD, are used to further modify the funding requirements by the assumption that unfunded carryovers will be priced higher in the following year. Table 4-2 illustrates how a set of original data is modified to reflect unfunded carryovers, with appropriate inflation of carryover requirements.

4.2.1.3.1.3 Procurement Lead Times

The model uses a lead time spread to express how spares are delivered over time. This spread is based on the assumption that the computed OA requirement for a single year is based on a wide variety of procurement lead times that can be described by a lead time distribution. The default values indicate that, for all the dollars obligated in a given year **n**, 30 percent result in deliveries in year **n + 1**, 40 percent in year **n + 2**, and 30 percent in year **n + 3**. The user may modify these factors with weapon system unique values, if justifiable. Table 4-3 illustrates two perspectives on lead times.

- Standard requirement lead times reflect how the requirement computation system anticipates delivery of a complete cross-section of items needed to fill future anticipated requirements.

Table 4-2. DLR Funding Summary with Carryover

FAMMAS v1.03d OUTPUT
CLASSIFICATION : UNCLASSIFIED
DATE : Oct 15, 1993
DATA DESCRIPTION : 93-94 PB
WEAPON SYSTEM : F-15

DLR Funding Summary (with Carryover)

F-15	1989	1990	1991	1992	1993	1994	1995	1996
BUY RQMT	165.4	113.4	213.5	140.8	199.8	236.9	253.4	262.0
BUY FUNDING	150.8	83.5	139.4	68.4	29.1	18.9	19.4	19.8
PERCENT	91.2%	73.6%	65.3%	48.6%	14.6%	8.0%	7.6%	7.6%
INIT SP RQMT	0.0	0.0	0.0	0.0	0.0	36.3	37.1	38.0
INIT SP FUNDING	0.0	0.0	0.0	0.0	0.0	36.3	37.1	38.0
PERCENT	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%
SSD RQMT	11.9	10.7	8.8	9.2	8.8	9.7	9.9	10.1
SSD FUNDING	10.5	9.7	8.8	9.2	8.8	9.7	9.9	10.1
PERCENT	88.2%	90.3%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
REPAIR RQMT	111.9	107.2	87.9	92.1	88.3	96.9	103.5	102.5
REPAIR FUNDING	104.5	96.6	87.9	92.1	88.3	80.0	99.2	101.4
PERCENT	93.4%	90.1%	100.0%	100.0%	100.0%	82.5%	95.8%	98.9%
TOTAL RQMT	277.3	220.6	301.4	233.0	288.1	370.1	394.0	402.6
TOTAL FUNDING	255.3	180.1	227.3	160.5	117.4	135.2	155.6	159.2
PERCENT	92.1%	81.6%	75.4%	68.9%	40.8%	36.5%	39.5%	39.6%

Table 4-3. Procurement Lead Time Data

Year	Standard Lead Time	----------- Planned Lead Time ----------- 1993	1994	1995	1996
n	.00	*.00*	*.00*	*.00*	*.00*
n+1	.30	*.30*	*.30*	*.30*	*.30*
n+2	.40	*.40*	*.40*	*.40*	*.40*
n+3	.30	*.30*	*.30*	*.30*	*.30*

---- All column totals must equal 1.00 ----

- Planned lead times reflect how item/system managers anticipate obligating available funds. For example, if RSD obligation authority is significantly below the computed requirement, a procurement strategy might be to order a larger than normal quantity of short lead time items to fill certain near-term shortages at the expense of long lead-time requirements, which may be less certain.

Table 4-4 is created by spreading year **n** buy requirements using standard lead times to reflect future-year delivery requirements. Note that the purpose of carrying three past years of requirements and funding data becomes apparent in order to complete the delivery requirement picture for the base year, which is used for curve calibration as described later in this section. Buy and initial spares requirements are combined in this

table to reflect the notion that, once received, DLR inventory loses its identity with respect to the source of funding.

Table 4-4. DLR Buy Program Delivery Profile

FAMMAS v1.03d OUTPUT
CLASSIFICATION : UNCLASSIFIED
DATE : Nov 09, 1993
DATA DESCRIPTION : 93-94 PB
WEAPON SYSTEM : F-15

Buy Program Delivery Profile

F-15	1989	1990	1991	1992	1993	1994	1995	1996
Total Buy Rqmt	165.4	113.4	213.5	140.8	199.8	273.2	290.5	300.0
Deliv. YR N-0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Deliv. YR N-1		49.6	34.0	64.1	42.3	59.9	81.9	87.2
Deliv. YR N-2			66.2	45.4	85.4	56.3	79.9	109.3
Deliv. YR N-3				49.6	34.0	64.1	42.3	59.9
Tot Rq'd Deliv				159.0	161.7	180.3	204.1	256.3
Buy Funding	150.8	83.5	139.4	68.4	29.1	55.2	56.5	57.8
Deliv. YR N-0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Deliv. YR N-1		45.2	25.1	41.8	20.5	8.7	16.6	16.9
Deliv. YR N-2			60.3	33.4	55.8	27.4	11.6	22.1
Deliv. YR N-3				45.2	25.1	41.8	20.5	8.7
Tot Fund Deliv				120.5	101.3	77.9	48.7	47.8
Pct Deliv Rqmt				75.7%	62.7%	43.2%	23.9%	18.6%

The second part of Table 4-4 is the funding analog and reflects the dollar value of expected DLR inventory deliveries based on approved funding levels and planned lead times as described above. Similar tables are created for repair and SSD deliveries.

4.2.1.3.1.4 DLR Delivered Support

Table 4-5 illustrates how FAMMAS summarizes the total DLR inventory delivery requirements and expected deliveries based on the funding profiles. Both buy and repair deliveries are incorporated in this table and combined to determine a total DLR inventory delivery requirement and total funded DLR deliveries. While SSD is not explicitly shown in this table, underfunding of SSD will result in a modification of deliveries from repair, reflecting the widely accepted notion that SSD funding shortfalls reduce the utility of repair funding since availability of repair parts is adversely affected.

Table 4-5. DLR Delivered Support

FAMMAS v1.03d OUTPUT
CLASSIFICATION : UNCLASSIFIED
DATE : Oct 15, 1993
DATA DESCRIPTION : 93-94 PB
WEAPON SYSTEM : F-15

Total DLR Delivered Support

F-15	1989	1990	1991	1992	1993	1994	1995	1996
BUY RQMT	0.0	0.0	0.0	159.0	161.7	180.3	204.1	256.3
BUY FUNDING	0.0	0.0	0.0	120.5	101.3	77.9	48.7	47.8
PERCENT	0.0%	0.0%	0.0%	75.7%	62.7%	43.2%	23.9%	18.6%
REPAIR RQMT	0.0	0.0	0.0	91.3	89.1	95.2	102.2	102.7
EFF FUNDING	0.0	0.0	0.0	91.2	89.1	81.7	95.3	101.0
PERCENT	0.0%	0.0%	0.0%	99.9%	100.0%	85.8%	93.3%	98.3%
TOTAL RSD RQMT	0.0	0.0	0.0	250.3	250.7	275.5	306.3	359.1
TOTAL RSD FUND	0.0	0.0	0.0	211.6	190.4	159.6	144.1	148.8
PERCENT	0.0%	0.0%	0.0%	84.5%	75.9%	57.9%	47.0%	41.4%
EXPECTED AVAIL				0.895	0.885	0.768	0.671	0.625

4.2.1.3.2 Model Adjustment Factors

Historical Mission Capable Rate Information – FAMMAS requires historical TNMCS and NMCM data for each weapon system. Historical TNMCS data are required for the base year and are used to calibrate the TNMCS marginal return curves. While not essential, similar data for the 3 years prior to the base year enable the model to better illustrate past trend information. The model uses historical NMCM data and projected future NMCM rates as input by the user. NMCM projections have been added solely for the purpose of providing MC rate projections as preferred by most users.

Current Year Adjustment – The model has an optional feature that allows the user to adjust future-year projections based on current weapon system TNMCS information. This feature may be toggled on or off, and the number of months in the current year for which the data is available must be specified. An example of how this feature works is as follows. Suppose the base year is 1992 (the model calibrates its estimating functions on base year delivered support and observed TNMCS rates). The model then estimates TNMCS rates for the years 1993-1996, based on funding profiles. However, if we are 9 months into 1993 and have actual TNMCS data through this period, the model will adjust the 1993 projection based on 3/4 of the year being known and will make minor modifications to years beyond 1993 if a significant difference between actual and predicted 1993 values is observed.

4.2.1.3.3 Analysis — Single Weapon System

4.2.1.3.3.1 Analytical Assumptions

The modified analysis framework of FAMMAS incorporates several basic assumptions, as follows:

- The buy, repair, and total DLR obligation authority requirements computed by AFMC are directly related to the availability target.

- Marginal return curves for funding vs. availability should incorporate simultaneous treatment of buy, repair, and initial spares funding and requirements (i.e., availability is a function of total DLR funding levels).

- The effectiveness of RSD-authorized repair funding is affected by authorized levels of procurement of repair parts through the SSD.

4.2.1.3.3.2 Availability Curves

The general form of the function relating funding to availability is:

$$y = 1 - a\, e^{-bx} \qquad \textbf{[Eq 4-18]}$$

where **y** represents weapon system availability and **x** represents the ratio of delivered funding to requirement. This form can be described as a marginal return curve, wherein the marginal decrease in availability per dollar becomes larger as funding decreases. This reflects the general understanding that a funding cut of a fixed amount from full funding has less impact on availability than the same cut from a lower funding level. In the former case, a number of workarounds can be effected that maintain aircraft readiness. However, as funding continues to decrease, effective workarounds are no longer available. After testing alternative approaches with historical data, the formulation of Equation 4-18 was determined to provide the most reasonable fit over the range of weapon systems analyzed.

The availability function is derived by fitting the curve of Equation 4-18 to two points. The lower point is y = 0.31 at x = 0. The value of 0.31 is the constant in the regression equation relating the Air Force's Aircraft Availability Model (AAM) estimate to the 1 - TNMCS rate. The upper point is derived from the base year availability value and funding ratio. The result is shown in Figure 4-11.

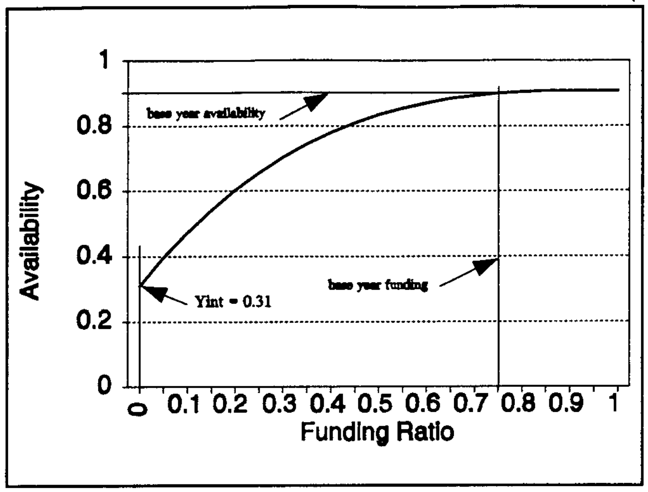

Figure 4-11. FAMMAS Availability Curve

In terms of the C code parameters, the estimated availability for year **y** is given by:

$$EstAvail(y) = 1 - \boldsymbol{AVal} \times \exp[\, - \boldsymbol{BVal} \times DlvdFundingRatio(y)] \qquad \textbf{[Eq 4-19]}$$

where

DlvdFundingRatio(**y**) = ratio of total delivered funding to total delivered requirement for the assessment year, **y**

BVal = exponential parameter

AVal = 1 - Yint (Y intercept, set to 0.31)

The BVal parameter is derived by fitting the curve to the two points: (x = 0, y = Yint) and (x = DlvdFundingRatio($_b$), y = Availability(y_b)). The equation for BVal is:

$$BVal = \frac{\ln(AVal) - \ln(1 - Availability(y_b))}{DlvdFundingRatio(y_b)} \qquad \textbf{[Eq 4-20]}$$

where

yb = base year

ln (**x**) = natural logarithm of **x**

Availability(y_b) = base year availability

DlvdFundingRatio(y_b) = ratio of total delivered funding to total delivered requirement for the base year.

When the current adjustment option has been selected, the projected availability is adjusted for the current year (base year plus one) and each subsequent year. The adjustment is based on the difference between the current

year availability value and the projected availability for that year, adjusted by the number of months covered by the current year observed availability (current month).

$$CurYrAdj = (CurrentAvail - EstAvail)\,\frac{CurrentMonth}{12} \qquad \text{[Eq 4-21]}$$

For example, if the base year is FY92 and the user has an FY93 availability estimate through March 1993, the current month is 6, which yields an adjustment of half of the difference between the estimated and observed availabilities for FY93. The adjustment factor is added to the estimated availability for each projected year, in a diminishing manner. That is, the full adjustment is made for the current year and halved for each subsequent year. The resulting adjusted availability estimate is given by

$$EstAvail\ (y)' = EstAvail\ (y) + CurYrAdj \times 0.5^{\,y\ -\ CurYr} \qquad \text{[Eq 4-22]}$$

4.2.1.3.4 Multiple Weapon System

4.2.1.3.4.1 Funding Allocation

Funding can be allocated across weapon systems in two alternative ways: equal proration or banding. The equal proration method simply spreads a user-specified funding cut or increase among the weapon systems so that each weapon system's funding increases or decreases by the same percentage. If this process results in funding exceeding the requirement for a given weapon system in a given year, the funding is set to the requirement value and the excess is spread over the remaining weapon systems. The funding for a weapon system after an increase or cut is given by:

$$Funding(w,y) = OrigFunding(w,y) + \frac{TotalFundingIncr(y)}{OrigTotalFunding(y)} \qquad \text{[Eq 4-23]}$$

where

Funding(w,y) = funding for weapon system w, year y after the increase/decrease

OrigFunding(w,y) = original funding for the weapon system

TotalFundingIncr(y) = funding increment (positive or negative)

OrigFunding(y) = original total funding for year y

This process can be applied to any of the funding categories.

Banding refers to the Air Force method for allocating RSD Buy funding among weapon systems according to a priority system. The primary weapon systems are divided into five bands with Band 1 getting the highest priority. The Aircraft Availability Model (AAM), which was designed to compute requirements based on the weapon system target availability, current inventory, and pipeline and cost parameters for aircraft components, is used to generate the funding value for each weapon system based upon its band. This is normally done for the first FYDP year only. This process generally results in significantly different percentages of funding to requirements within each band. The FAMMAS model does not attempt to duplicate this complex process, as it is neither necessary nor feasible. Rather, the model uses the results of the banding computation for the first FYDP year to determine the allocation for the subsequent years. The allocation scheme simply consists of attempting to allocate funding among weapon systems for a given year so that each weapon system receives the same proportion of total RSD Buy funding as it received for the banded year. If funding exceeds the requirement for a weapon system, its funding is set equal to the requirement and the excess is reallocated among the remaining weapon systems.

$$Funding(w,y_1) = \frac{Funding(w,y_0)}{TotalFunding(y_0)} \, TotalFunding(y_1) \qquad \text{[Eq 4-24]}$$

where

Funding(w, y) = funding for weapon system w, year y

TotalFunding(y) = total funding for year y

y_0 = banding year

y_1 = funding allocation year

4.2.1.3.4.2 Group MC Rates

Weapon systems can be combined into groups by the user. The output reports then display the MC rates and funding values by weapon system and group, as well as the total for all selected weapon systems. The rates are combined by using annual flying hours as the weighting factor.

$$GrpMCRate = \frac{\sum_{w} MCRate(w) \times FlyingHrs(w)}{\sum_{w} FlyingHrs(w)} \qquad \text{[Eq 4-25]}$$

where

GrpMCRate = Average projected MC rate for the group

MCRate(w) = projected MC rate for weapon system w

FlyingHrs(w) = annual projected flying hours for weapon system w

The overall MC rate is determined in the same manner.

4.2.1.3.5 Model Outputs

The FAMMAS Model may be operated in a stand-alone mode called from WINLAM. In its stand-alone version for single weapon systems, the following outputs are available:

- Annual DLR (RSD) and SSD stand-alone and carryover funding summaries
- Annual DLR delivered support summaries
- Past, current, and projected availability profile (tabular and graphic)
- Projected TNMCS, NMCM, and MC rates

When operating with WINLAM, FAMMAS provides data for each projection year that are used for both peacetime materiel readiness projections and wartime analyses in the Global Reach Module (for airlift aircraft) and Global Power Module (for fighters, bombers, and aerial refueling aircraft). Pertinent data include:

- Projected DLR delivered funding and requirements
- Projected TNMCS, and NMCM rates

The operation of FAMMAS from WINLAM and automatic transfer of these data have been implemented in the current versions of the model.

The primary output screens and tables for the multiple weapon system mode of FAMMAS are identical in format to the single weapon system outputs. The only difference is that the requirement/funding values are summed over all weapon systems in the group analyzed and the MC/NMC rates are determined from a weighted average of the values of the individual weapon system in the group.

4.2.2 GLOBAL POWER MODULE SYSTEM FUNCTIONS

4.2.2.1 Assessment Environment

Input parameters for GPM, also known as TLAM, consist of four types: user inputs, run-time parameters, system administration variables, and model constants. The first are those parameters entered by the user or obtained from the File Management System. Run-time parameters specify options and values that control the running of the model, such as number of days, inclusion of attrition, etc. System administration variables are MD-specific policy variables such as direct support objective (DSO), etc. Model constants comprise a set of

factors that reflect Air Force policies or result from model calibration. System administration variables and the model constants can only be changed by the System Administrator (AF/LGSI).

The assessment framework of multiple engagements in multiple theaters is reflected in the force structuring options, which the user can create/edit within WINLAM. Aircraft inventory consists of five categories:

- Primary aircraft authorized (PAA)
- Backup aircraft inventory (BAI)
- Attrition reserve (ATR)
- Test aircraft
- In depot maintenance

The sum of the first four quantities less the fifth represents the number of possessed aircraft. Four theaters are available: three active theaters and an uncommitted theater for aircraft not deployed to one of the active theaters.

Aircraft inventory are available for analysis within seven force structure sources (ACC, U.S. Air Force in Europe [USAFE], Pacific Air Forces [PACAF], ANG, AFR, etc.). PAA, BAI, ATR, and Test quantities are associated with each source and so facilitate force allocations to multiple theaters while assuring that specific sourcing does not exceed available forces. Test aircraft are included in the input data screen only for purposes of completeness. They are not included in the analysis.

4.2.2.2 Computational Process

The computational program is structured in terms of four primary procedures that perform the following functions:

- Determine the total aircraft inventory (TAI), backup aircraft inventory (BAI), and attrition reserve (ATR) at the beginning of the combat period (procedure SetForceRecBAITAI).

- Set the scheduled PAA, sortie rate, maximum turn rate, and sortie duration for each day and each theater based on the Theater Rate Tables and Wartime Tasking Records (procedure ReqSandPAA).

- Compute the calibration parameters for the aircraft and engine supply function (TNMCS) and the aircraft maintenance function (NMCM) computations (procedure calcCalibration).

- Perform the day-to-day computation of MC rates and sorties flown (procedure calcTLAM).

The dynamic segment of the program computes the day-by-day mission capable rates and sorties generated, by theater as well as worldwide according to the following process, depicted in Figure 4-12.

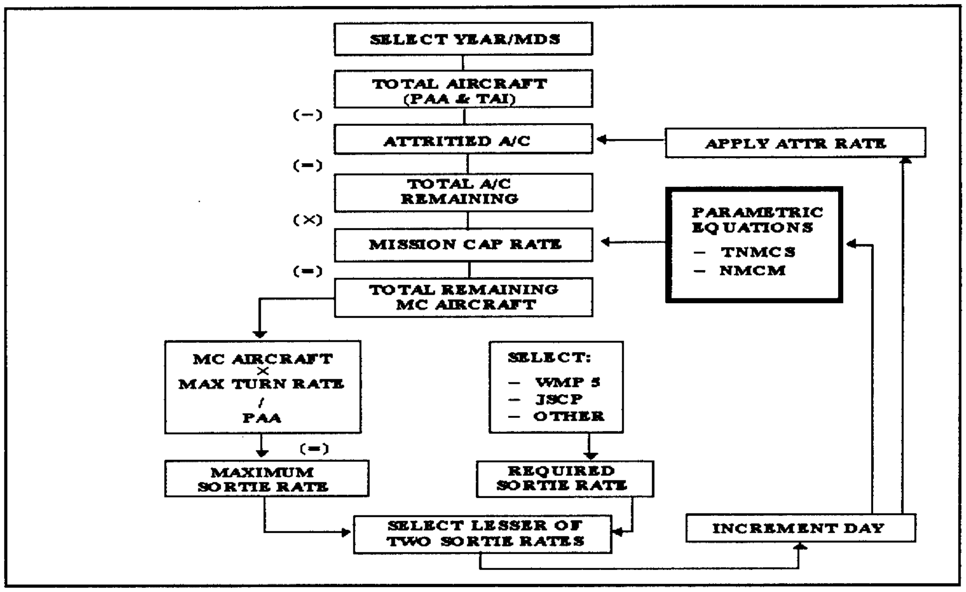

Figure 4-12. TLAM Computational Algorithm

- For each day, the number of aircraft available in each theater is determined from the aircraft in the theater at the end of the previous day plus aircraft deployed on that day minus aircraft leaving the theater minus attrited aircraft, if any, plus filler aircraft.

- At the beginning of each day, the number of mission capable (MC) aircraft is based on the MC rate from the end of the previous day and the remaining number of aircraft. For the first day, the peacetime values are used.

- Sorties flown are determined by comparing the maximum sortie capability (computed as the product of total MC aircraft available, maximum turn rate, and massing factor) and the required sorties (defined by the input variables). The lesser value is selected and becomes the number of sorties flown.

- Attrited aircraft for that day, computed from the sorties and the attrition rate per sortie, are added to the cumulative attrited aircraft value. The cumulative number of filler aircraft used to offset attrition is also computed.

- At the end of the day, the MC rate is recomputed based on the flown sorties, as reflected in the cumulative activity ratio and the available maintenance hours per flying hour. This MC rate is then applied for the generation of sorties on the following day.

The primary outputs are the MC rate and sorties flown for each combat day. However, other output variables are computed during a run and stored in arrays for either tabular or graphic output. These arrays can be stored in ASCII format for easy access and creation of display templates using Harvard Graphics software. An internal graphics feature is available for reviewing the output data without exiting WINLAM.

4.2.2.2.1 Allocation of PAA to Theaters

Force allocation, time-phased allocation of aircraft to different theaters, is accomplished by user-editable wartime tasking records. There are five data elements in a tasking record. Theater Designator identifies the theater. Three combat theaters are available for allocation. Not all theaters need to be used. Aircraft not allocated are carried in a fourth theater file and designated as Uncommitted. Source Designator identifies the source in the force structure file. Deployed Aircraft identifies the number of PAA to be deployed from a designated source to a designated theater. Arrival Day specifies when the aircraft arrive in a designated theater. Departure Day allows the aircraft to be returned to the original source so that they may be redeployed if necessary. The force allocation records provide the user with a wide range of flexibility to deploy, employ, and redeploy aircraft in a complex multitheater scenario.

An event timeline is available in the edit menus to differentiate between start times in multiple scenario setups. The event timeline includes a C-Day (the day on which movement from the origin in a deployment operation commences) and D-Day (the day on which conflict begins) for each theater. The arrival and departure days reflected in the tasking records are relative to the C-Day for the theater into which the aircraft are deployed. Tasking data are obtained from the War Mobilization Plan 5 (WMP-5) database, which is classified. Tasking data in the Unclassified implementation of the model are nominal only.

4.2.2.2.2 Development of Theater Operational Parameters

Scheduled sortie rates, maximum turn rates, sortie durations, and attrition rates are specified by theater and time period. As in the case of theater PAA, the user-specified periods are relative to CDay + InPlaceDay for each force record and theater. One set of values is given for the period from CDay to Day; additional values are given by user-specified periods. Attrition rates, maximum turn rates, and sortie durations are translated to daily

values and directly utilized in the day-to-day section of the program. Theater and global weighted averages are computed for scheduled sortie rates. First, required sorties for day i over all theaters are given by:

$$\boldsymbol{ReqS(i)} = \sum_t \sum_s \boldsymbol{SR(i,t)} \times \boldsymbol{DeployedAC(s,t)} \qquad \text{[Eq 4-26]}$$

where SR(i,t) is equal to the required sortie rate specified for the time period into which i falls. The required sorties for theater t on day i are:

$$\boldsymbol{ThtReqS(i,t)} = \sum_s \boldsymbol{SR(i,t)} \times \boldsymbol{DeployedAC(s,t)} \qquad \text{[Eq 4-27]}$$

To help clarify the assignment of aircraft to the theaters and the generation of theater-based scheduled sortie rate, an example will be presented. Assume a scenario with two theaters and an operational period of 90 days. The C-Day for Theater 1 is automatically set to day 0, since the first theater is always identified with the initiation of deployment for the scenario. The C-Day for Theater 2 is day 10 and the D-Day is day 15. The example addresses this theater only, to demonstrate the relationships between day 0, C-Day, D-Day, the force deployment/departure days, and the sortie surge/sustained days. Table 4-6 shows the Force Record data. The days specified in the records are relative to the C-Day for the specified theater. Two deployments are made: 50 aircraft to the theater on day 0 relative to C-Day (scenario day 10) and 20 aircraft on day 20. The first aircraft group leaves the theater on day 40. The theater sortie rates are shown in Table 4-7. During the period between C-Day and D-Day, the aircraft are scheduled to fly 0.8 sorties per aircraft per day. On D-Day they begin the surge rate, 2.5, and on D-Day plus 7 they are scheduled to fly the sustained rate, 1.2. A unit first begins to fly the surge rate on D-Day if it is in the theater at that time, or when it arrives in the theater if its arrival day is after the theater D-Day. The resulting theater sortie rate and PAA values are shown in Table 4-8.

Table 4-6. Sample Force Record Data

	Force Record 1	Force Record 2
Source	ACC	USAFE
Theater	Thtr 2	Thtr 2
PAA	50	20
In-Place Day*	0	20
Depart Day*	40	90

* Relative to C-Day

Table 4-7. Example Theater 2 Sortie Rates

Period	Sortie Rate	Rate Type
C-Day to D-Day	0.80	Peace
0 - 6*	2.50	Surge
7 - 89*	1.20	Sustained

* Relative to D-Day

Table 4-8. Example PAA and Required Sortie Rates in Theater 2 by Period

		Force Record 1		Force Record 2		Total	
Period	SR Type	PAA	SR	PAA	SR	PAA	SR
0 - 9	0 - C-Day	0	0	0	0	0	0
10 - 14	C-Day - D-Day	50	0.80	0	0	50	0.80
15 - 21	Surge 1	50	2.50	0	0	50	2.50
22 - 29	Sust 1	50	1.20	0	0	50	1.20
30 - 36	Surge 2	50	1.20	20	2.50	70	1.57
37 - 49	Sust 1 & 2	50	1.20	20	1.20	70	1.20
50 - 89	Sust 1	0	0	20	1.20	20	1.20

Nothing is happening in the theater from the first 10 days (day 0 to day 9) since the first aircraft are no deployed until day 10. On this day, the first force of 50 aircraft are deployed to the theater. They (attempt to) fly at a required sortie rate of 0.80 until D-Day (day 15). From day 15 through day 21 this force flies the surge rate (2.50). On day 22 it begins flying the sustained rate. The second force is deployed on day 30, at which time it begins flying the surge rate. Over the next 7 days, the theater required sortie rate is 1.57, the composite of the sustained rate for the first force and the surge rate for the second force. After this period, until the first force leaves the theater on day 49, both forces fly the sustained rate. During the final 40 days, the remaining force continues to fly the sustained rate.

4.2.2.2.3 Computation of Aircraft Quantities by Theater

The total initial TAI, representing possessed aircraft in the model, is determined by summing the total PAA, BAI, and ATR quantities and subtracting aircraft in the depot.

$$TotTAI = TotPAA + TotBAI + TotATR - TotDepotAC \qquad \text{[Eq 4-28]}$$

Test aircraft are excluded from the computation. TotATR in represents aircraft designated as attrition reserve. The model recomputes the initial attrition reserve as the difference between the total TAI and total PAA values. If TAI is less than PAA because of a relatively large number of aircraft in the depot, then ATR is set to zero. Consequently, some PAA aircraft may be used as attrition reserve if there are sufficient quantities to more than offset the aircraft in depot maintenance.

$$TotATR = max(TotTAI - TotPAA,\ 0) \qquad \text{[Eq 4-29]}$$

As noted above, the model allows up to three active theaters to be defined. Aircraft not deployed to an active theater remain in a fourth theater, labeled Uncommitted, where they normally fly at peacetime rates. At the beginning of the day-to-day computation, all aircraft are placed in the Uncommitted Theater. Their initial MC rates are equal to the peacetime rate. Aircraft are then deployed to each theater based upon the force allocation records described in Section 4.3.2.3.1. Recall that the allocation records specify the PAA quantities to be deployed on the indicated days. Additional BAI may be deployed along with the PAA, depending upon the availability of such aircraft and the user's selection.

Two options are available for BAI allocation. The first option allocates the BAI to each deployed force in proportion to the PAA in that force. The second applies a maximum value, defined in the Model Constants file, to the allocation proportion. This option can be used to limit to the number of BAI per squadron to a reasonable number, in the event that the input data contain an unusually large number of BAI.

The variable ThtDeployment(i,t) represents the PAA scheduled for deployment to theater t on day i. The allocation of BAI is accomplished as follows:

$$\begin{aligned} BAIFct &= \min\left(\frac{totBAI}{totPAA},\ BAIInputFct \right) \\ DeployedBAI &= BAIFct \times ThtDeployment \end{aligned} \qquad \text{[Eq 4-30]}$$

where

ThtDeployment(i,t)= PAA deployed to theater *t* on day *i*

BAIFct = BAI allocation proportion

BAIInputFct = limitation on BAI allocation, if the user selects that option

4.2.2.2.4 Day-to-Day Computation

After establishing the theater PAA, sortie rate, etc., the calibration parameters for the TNMCS and NMCM are computed. This process is described in the discussion of the supply and maintenance functions. Prior to the day-to-day computation of aircraft availability and sortie generation, all aircraft, TotTAI, are placed in the Uncommitted theater. The initial number of mission capable aircraft in that theater is set equal to the product of the peacetime MC rate and TotTAI. The parameter expressing the number of remaining aircraft in each theater after attrition, ThtRemAcft(i,t), is set equal to TotTAI for the Uncommitted theater and zero for the three active theaters.

Within the daily loop, three theater loops are imbedded. The first loop determines the number of remaining aircraft in each theater at the beginning of each day, taking into account attrition and filler aircraft. Filler aircraft are attrition reserve aircraft used to offset attrited aircraft. At the beginning of each day, the number of aircraft remaining in a theater after the attrition and filler replacement (if any) during the previous day are computed by:

$$ThtRemAcft(i,t) = ThtRemAcft(i-1,t) - AttrAcft(t) + ThtFillerAC(t) \qquad \textbf{[Eq 4-31]}$$

where

ThtRemAcft(i,t)= remaining aircraft in theater t at the beginning of day i

AttrAcft(t) = aircraft attrited in theater t on the previous day

ThtFillerAC(t)= attrition reserve aircraft used to replace attrited aircraft in theater t on the previous day.

The second loop deploys aircraft among theaters based upon tasking records, which specify the number of aircraft scheduled for deployment on specific days, constrained by the number of available aircraft in the source theater.

The number of mission capable aircraft in theater t at the beginning of day i, before deployment, is given by:

$$ThtMCAcft(i,t) = tMC(t) \times ThtRemAcft(i,t) \qquad \textbf{[Eq 4-32]}$$

where tMC(t) is the mission capable rate at the end of the previous day. Deployment of aircraft from the uncommitted theater to one of the active theaters is accomplished at the beginning of each deployment day. It is assumed that only aircraft that are mission capable at the time of deployment will be sent to the theater. It is further assumed that NMCM aircraft can be repaired in time for deployment while TNMCS aircraft cannot. Therefore, the actual number of aircraft deployed may be less than the scheduled number. With only mission capable aircraft being deployed, the initial TNMCS rate for those aircraft is assumed to be zero, disregarding possible component failures during the flight to the theater. If there are already aircraft i the theater, the new TNMCS rate at the beginning of the deployment day will be a weighted average of the latest rate for aircraft in the theater before deployment and rate for the newly deployed aircraft (zero). The NMCM rate remains unchanged. Thus the MC rate for the active theater will increase and the rate for the Uncommitted theater will correspondingly decrease when aircraft are deployed.

4.2.2.2.5 Computation of Sorties Flown

The third theater loop includes the computation of the TNMCS and NMCM rates as well as the sorties flown. The number of sorties flown depends upon the maximum capability to generate sorties, constrained by logistical and operational factors, and the number of sorties scheduled. Maximum sortie generation capability, denoted maximum sorties in the model, is based on the number of mission capable aircraft, the maximum turn rate per aircraft, and a massing factor. The effect of massing, or grouping a number of sorties for launch in a short period of time, has long been understood. Servicing and maintenance resources are taxed and overall sortie availability is somewhat reduced. The effect of massing has been studied and a massing constraint has been added to the model.

The massing requirement is included as a user-editable variable. A default value is included in each GPM weapon system file that can be changed by the user prior to entering the run-time mode. Access to this variable is through the edit routines under the operational files submenu. Currently, only values tested may be entered (i.e., 1, 2, 4, 8, or 12), which represent the number of sorties per flight. A value of 1 results in no effect due to massing.

A binomial statistical module has been inserted in the calibration section of code that creates a degradation table whenever the model is run. The module computes the maximum number of sorties that can be generated for a given squadron size and maximum turn rate over a range of MC rates of 1 to 100 percent for a baseline case (massing size = 1) and the user-specified massing size. The baseline case is computed as in the MaxS computation shown below while the massing factor case is determined by application of binomial probabilities.

For example, assume the massing factor is 4 with a squadron size of 24 and a maximum turn rate of 3. If less than 4 aircraft are available, no sorties are launched. If between 4 and 7 aircraft are available, 12 sorties (4 aircraft x 3 turns per aircraft) can be launched, etc. The probabilities of 0 - 3, 4 - 7, etc. available aircraft are computed for each MC value and combined to obtain the total expected number of sorties. These values are divided by baseline sorties, yielding a table of massing degradation factors, MassFactor(MC).

Applying the maximum turn rate and the massing factor to the total number of MC aircraft yields the maximum number of sorties than can be flown on a given day.

$$ThtMaxS(i,t) = ThtMcAcft(i,t) \times ThtMaxTurnR(i,t) \times MassFactor \qquad \text{[Eq 4-33]}$$

The total number of sorties flown on a given day is the minimum of the maximum achievable sorties and the required number of sorties. The latter is determined from the number of deployed PAA and the scheduled sortie rate for that day. Total sorties flown is given by:

$$ThtFlwnS(i,t) = Min[ThtMaxS(i,t), ThtReqS(i,t)] \qquad \text{[Eq 4-34]}$$

The number of attrited aircraft are based on the attrition rate per sortie and the sorties flown. The number of aircraft attrited for day i is added to the cumulative quantity through day i - 1. The cumulative total is given by:

$$ThtCumAttrAcft(i,t) = \sum_{j=0}^{i} ThtFlwnS(j,t) \times AttrR(j,t) \qquad \text{[Eq 4-35]}$$

where

AttrR(j,t) = attrition rate for day j, theater t (input)

If there are attrition reserve aircraft (located in the uncommitted theater), they can be used as fillers to offset the attrited aircraft. Attrition reserve aircraft are allocated among theaters on the basis of the ratio of the net cumulative attrited aircraft (cumulative attrited less cumulative filler aircraft) to the remaining aircraft for each theater.

$$Ratio(t) = \frac{ThtCumAttrAcft(i,t) - ThtCumFillerAC(i,t)}{ThtRemAcft(i,t)} \qquad \text{[Eq 4-36]}$$

One aircraft is moved at a time from attrition reserve to filler status for the theater with the maximum Ratio(t) value. The process proceeds iteratively until the attrition reserve supply is exhausted or all attrited aircraft have been replaced by filler aircraft.

4.2.2.2.6 Aircraft Availability

The number of sorties flown depends upon aircraft availability, measured in terms of the mission capable (MC) rate. As noted earlier in this document, the MC rate can be expressed in terms of two not mission capable rates: total not mission capable, supply (TNMCS) and not mission capable maintenance (NMCM).

$$MC = 1 - (TNMCS + NMCM) \qquad \textbf{[Eq 4-37]}$$

TNMCS is estimated from the supply function and NMCM from the maintenance function.

4.2.2.2.7 Supply Function

4.2.2.2.7.1 General Discussion

When an aircraft is not operational because it is waiting for a spare part, it is said to be TNMCS (total not mission capable, supply). The TNMCS rate is the average proportion of time spent awaiting a spare part for some population of aircraft. Such rates are measured at squadron, base, MAJCOM, and Air Force-wide levels for all major aircraft types. Additionally, period averages are used to plot trends and measure the degree of supply support (daily, weekly, monthly, quarterly, annually).

Many different resource programs contribute to the TNMCS rates of aircraft systems. Some of the most obvious and critical programs that affect supply support are:

- Replenishment spares inventories
  - -- Peacetime operating spares (POS)
  - -- Readiness spares packages (RSP)
  - -- Other war reserve materiel (OWRM)

The general parametric form used to model supply support is the negative exponential curve:

$$Y = C + Ae^{-bt} \qquad \textbf{[Eq 4-38]}$$

This general function is useful in describing many phenomena that exhibit degradation over time. Models, such as Dyna-METRIC, commonly used by the Air Force for assessment of wartime sortie generation capability, typically exhibit a degradation over time in the 1-TNMCS status of aircraft flying a wartime operating profile. Such analytically derived output curves are similar in shape to the general parametric form shown above when b is positive and $C + A \leq 1.0$. Additionally, this functional form has certain characteristics that are both intuitively and logically relatable to a number of supply system planning and programming parameters.

4.2.2.2.7.2 Behavioral Characteristics of the Function

In general, when the degradation rate is positive (when $b > 0$), and $C + A \leq 1.0$, the function appears as shown in Figure 4-13, where t (time) is the independent variable.

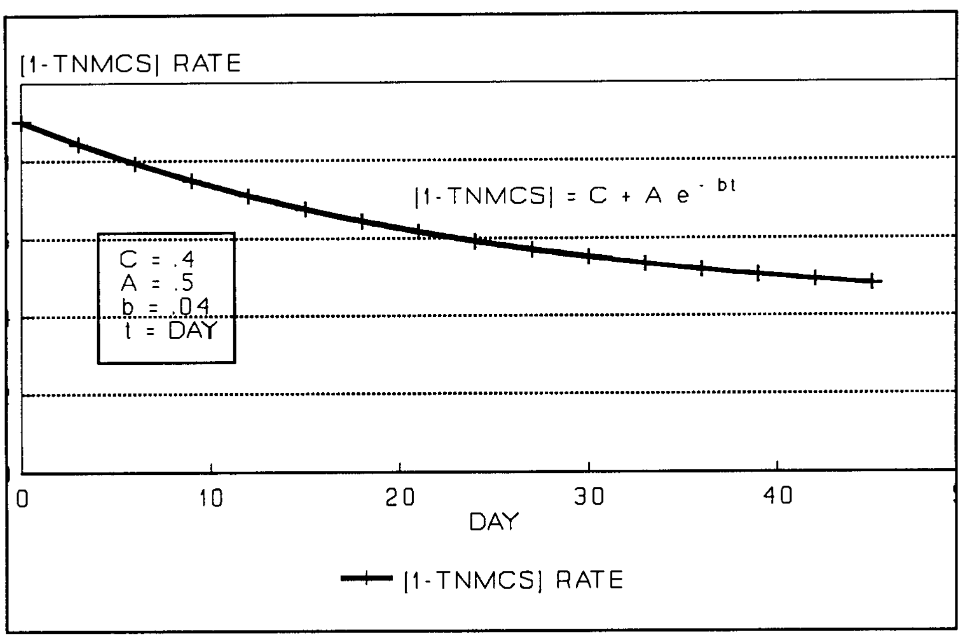

Figure 4-13. Supply Degradation Function

Note that the value of Y approaches C as t increases and $Y = C + A$ at $t = 0$. If the value of b in the function is varied, the degradation rate varies as shown in Figure 4-14.

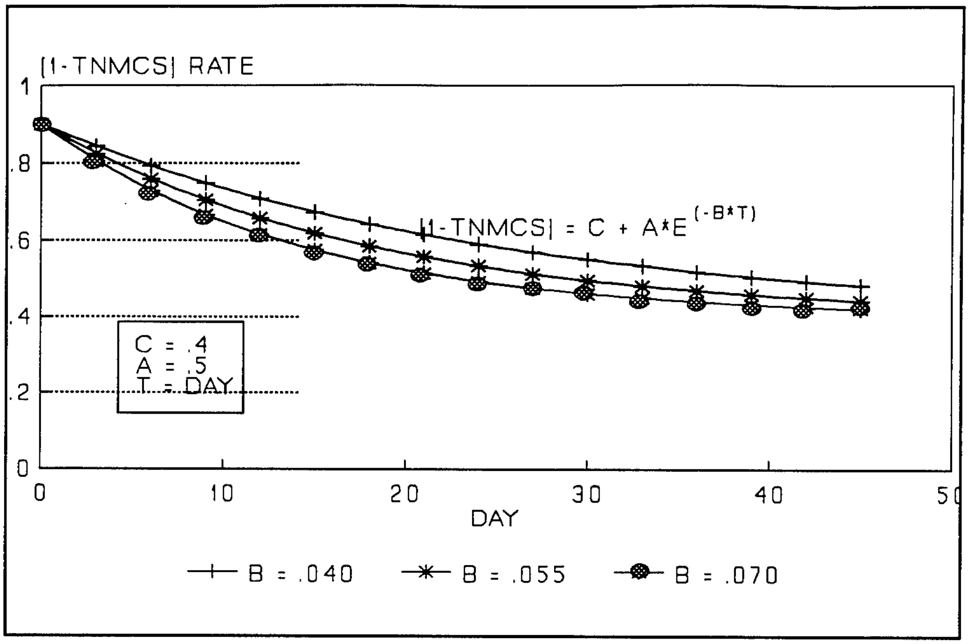

Figure 4-14. Supply Degradation as a Function of B

4.2.2.2.7.3 Application in TLAM

In TLAM, the challenge was to develop a general estimating function that would describe the degradation of 1-TNMCS rates under conditions of wartime utilization (sortie rates) that greatly exceed normal peacetime rates. The general estimating function previously described was selected and specifically applied as described next. The general equation is:

$$[1 - TNMCS] = C + Ae^{-Bu} \qquad \text{[Eq 4-39]}$$

where the independent variable, u, is a function of aircraft activity over time, and the parameters C, A, and B are each controlled by a series of parametric computations that are related to funding for specific resource programs. Note that C represents the minimum value of 1 - TNMCS.

The three parameters are developed from calibration on baseline parameters relating to the full funding case with additional parameters reflecting degradation due to resource shortfalls. Thus:

$$C = C_0 \times C_1$$
$$A = A_0 \qquad \text{[Eq 4-40]}$$
$$B = \frac{B_0}{B_1}$$

where

C_0 = calibration parameter for C

C_1 = peacetime spares funding parameter

A_0 = calibration parameter for A

B_0 = calibration parameter for B

B_1 = RSP funding parameter

The variable *u* in Equation 4-39 is the cumulative activity ratio (CumActRatio), that reflects the wartime sortie activity over the period relative to the daily peacetime number of sorties. That is, the value of u for day i is:

$$u = CumActvRatio(i) = \sum_{j=1}^{i} \frac{FlwnS(j) - PeaceS}{PeaceS} \qquad \text{[Eq 4-41]}$$

where

FlwnS(j) = number of sorties flow on day j

PeaceS = daily number of peacetime sorties

4.2.2.2.7.4 Initial Calibration (General Case)

If all logistic programs are related to nonbaseline variables and if they are fully funded, then all nonbaseline variables are set to 1.0 and the equation reduces to:

$$[1 - TNMCS] = C_0 + A_0 e^{-B_0 u} \qquad \text{[Eq 4-42]}$$

The independent variable, *u*, represents the time dimension of the function. It serves to map time into cumulative aircraft activity. Since a resource consumption function and resources are consumed by activity (aircraft sorties) that may not proceed at a constant daily level, this mapping allows the function to be calibrated to variable daily activity levels. In the discussion that follows, the first day of combat is considered as Day 0.

The calibration process requires the following input information:

- Wartime Direct Support Objective (DSO) — The minimum proportion of aircraft not in TNMCS status after a specified number of days of wartime flying activity. This policy variable is used by the Air Force in the determination of the size and composition of the readiness spare kit (RSP) requirements. Nominally, the DSO period consists of a specified number of days at a surge sortie

rate followed by a specified number of days at a sustained rate. Two options are available. Under the dual DSO option, generally applied to fighter aircraft, kit requirements are developed to achieve a specified DSO level after the surge period and a second level at the end of the sustained period. Under the single DSO option, the DSO level relates to a single period at a specified (surge) rate. The System Administrator can specify the dual/single DSO option, sortie rates, and the parameters from which the DSO values are computed.

- Peacetime Activity Rate — Sorties per day required in peacetime. There are peacetime rates for the current year (CurPeaceSR) and the target year (TgtPeaceSR).

- Wartime Activity Rates — Sorties per day required for wartime. For tactical forces, this is abbreviated as SurgSR or SustSR (surge or sustained sortie rates).

To derive the value of the calibration variables C_0, B_0, and A_0, the following process is applied. This discussion assumes a surge period of 7 days (day 0 through day 6) followed by a sustained period of 23 days (day 7 through day 29). However, these periods are not fixed. They can be specified by the System Administrator.

If wartime spares support is fully funded, then the value of [1-TNMCS] at the beginning of Day 0 (before the initiation of combat) will equal 1.0:

$$[1 - TNMCS]\ (Day\ 0) = C_0 + A_0 = 1.0 \qquad \textbf{[Eq 4-43]}$$

and at the end of Day 29, the function will yield the DSO when the aircraft are operated at the required surge or sustained rate and the activity variable (u) is incremented accordingly.

$$[1 - TNMCS]\ (Day\ 29) = DSO \qquad \textbf{[Eq 4-44]}$$

Further, since the value of the function approaches C_0 as the value of u increases, it can be hypothesized that the C_0 is related directly to the ratio of wartime surge to peacetime levels of activity:

$$C_0 = \frac{TrgPeaceSR}{SurgSR} \qquad \textbf{[Eq 4-45]}$$

Equation 4-45 is subject to the constraint that $C_0 \leq 1.0$ to prevent the following equation from yielding a negative value.

$$A_0 = 1.0 - C_0 \qquad \textbf{[Eq 4-46]}$$

Finally, B_0, the expected degradation rate in a fully funded situation, can be determined by the equation:

$$B_0 = \frac{\ln(A_0) - \ln(DSO - C_0)}{u} \qquad \textbf{[Eq 4-47]}$$

where u = the number of units of peacetime activity over the specified wartime period, or:

For DSO days = 30:

$$u = \frac{7\ (SurgSR - TrgPeaceSR) + 23\ (SustSR - TrgPeaceSR)}{TrgPeaceSR} \qquad \textbf{[Eq 4-48]}$$

For DSO days = 7:

$$u = \frac{7\ (SurgSR - TrgPeaceSR)}{TrgPeaceSR} \qquad \textbf{[Eq 4-49]}$$

For the single DSO option the calibration parameters fit the curve to the DSO value for the specified number of surge days under full funding. The dual DSO option provides a fit for both the surge and sustained periods, as specified in the current rules for developing fighter aircraft RSP. To accomplish this, two curves are generated: one from Day 0 to the end of the surge period (Day 6) and the other from the beginning (Day 7) to the end (Day 29) of the sustained period. For the first period, the A_0 and B_0 values are the same as the 7-day DSO parameters specified in Equations 4-46 and 4-47, with the cumulative activity ratio, u, specified by Equation 4-49. The second curve is specified by A_0 and B_0 parameters that yield the appropriate DSO value on day 29 and that provide continuity for the transition between the two curves. This transition point is based on the value of the cumulative activity ratio, u(7), that would result from 7 days of flying sorties at the surge rate. If the number of sorties actually flown per day is less than the scheduled rate, the u(7) value is reached sometime after Day 6. The model checks for this threshold (denoted DualDSOActFct in the program) to determine when to shift from the first curve to the second.

The B_0 value for the second curve is given by:

$$B_0' = \frac{\ln (DSO_7 - C_0) - \ln (DSO_{30} - C_0)}{u} \qquad \text{[Eq 4-50]}$$

where

$$u = \frac{23\ (SustSR - PeaceSR)}{PeaceSR} \qquad \text{[Eq 4-51]}$$

The parameter B is replaced by:

$$B' = \frac{B_0'}{B_1} \qquad \text{[Eq 4-52]}$$

To assure the continuity between the curves, a new A factor is used in Equation 4-39:

$$A' = [1 - TNMCS(i - 1) - C]\ e^{B'\,u(7)} \qquad \text{[Eq 4-53]}$$

where

i	= day of transition (i.e., the activity ratio has reached the u(7) value)
u(7)	= activity ratio through the first 7 days under the scheduled flying program
TNMCS(i-1)	= TNMCS value at the end of Day i-1

The C parameter remains the same for both curves. The second curve is used for the remained of the analysis period, unless the cumulative activity ratio becomes less than the threshold, u(7), in which case the program switches back to the first curve. This can occur if the flown sortie rate becomes less than the peacetime rate over a period of time, as can be seen from Equation 4-49.

4.2.2.2.7.5 Supply Function Parametric Variables

Following the general form previously discussed, parametric variables have been selected to affect the supply support function in intuitively logical ways. The rationale and valuation for each is discussed in the following sections.

Replenishment Spares — The variable C_1 is used to estimate the effect of spares funding on TNMCS. Shortfalls in spares funding are assumed to be reflected in the initial (peacetime) TNMCS rate, ITNMCS. The term C_0 x C_1 represents the C calibration factor modified by the spares funding situation. Replacing C_0 in Equation 4-43 with C_0 x C_1, and solving for C_1 yields

$$C_1 = 1 - \frac{ITNMCS}{C_0} \qquad \text{[Eq 4-54]}$$

The impact of Readiness Spares Package (RSP) asset availability is reflected in the B_1 factor (B1Fct). A minimum is set for the factor by the parameter SWAPFct, which is set in the Model Constants File. B_1 is directly related to the value of spares on hand relative to the gross RSP requirement for the analysis year. The on-hand value is estimated by the gross RSP requirement less the spares funding shortfall. As the Air Force has instituted a spare-is-a-spare policy, which does not differentiate between RSP and POS buys, single annual requirement and funding values are used for spares. The annual funding and requirement values for procurement of spares (denoted buy requirement and funding) are assumed to be in the form of "delivered" dollars, which takes into account procurement lead times. That is, delivered funding dollars for the analysis year represent the value of the assets delivered to the Air Force during that year. The B_1 factor is computed by:

$$B_1 = SWAPFct + (1 - SWAPFct)\,\frac{GrossRSPReq - DlvBuyShortFall}{GrossRSPReq} \qquad \text{[Eq 4-55]}$$

where

SWAPFct	= minimum value for B_1 (default = 0.025)
GrossRSPReq	= gross RSP requirement
DlvBuyShortFall	= shortfall in delivered assets = DlvBuyReq - DlvBuyFnd
DlvBuyReq	= delivered buy requirement for both RSP and POS
DlvBuyFnd	= delivered buy funding for both RSP and POS

If RSP and POS are fully funded, $B_1 = 1.0$ and the degradation rate is controlled by the value of B_0, which was calibrated to meet the specified DSO. If RSP and POS requirements are not fully funded, $B_1 < 1.0$ and the degradation rate is increased.

Other War Reserve Materiel (OWRM) — OWRM funding and requirement data have been incorporated in a recovery function described in greater detail in the following sections.

4.2.2.2.7.6 Supply System Recovery Factor

To estimate the effects of enhanced support capability on sustainability after some period of combat, a system recovery function has been employed. Requirement computations for RSP stocks take into consideration certain planning assumptions that will alter the consumption and replacement patterns of spares after various periods of time. For instance, it is assumed that several weeks after the deployment of combat units and their RSPs, a follow-on off-equipment maintenance capability will be deployed. Additionally, as transportation links between depots and bases are completed, repaired components from the depots will become available. The

extent and timing of the recovery depend upon the peacetime and wartime spares stocks, depot repair times, order and ship times, and the depot-base connection day.

The model employs a recovery factor to emulate the effect of these programs on supply system recovery. The function allows the [1 - TNMCS] rate to increase over time, asymptotically approaching a specific value. The beginning day of recovery is denoted RcvDay. For day i, after RcvDay, the function is computed by summing daily values.

$$CumRcvFct(i) = \sum_{j=RcvDay}^{i} \frac{8 \times RcvAlpha \times RcvGamma}{(j - RcvBeta)^2 + 4 \times RcvGamma^2} \qquad \text{[Eq 4-56]}$$

This sum is an approximation to the arctan function whose basic shape is depicted in Figure 4-15. (The factor pi/2 is added to make the function positive over the range of x values.)

$$4 \times RcvAlpha \times \arctan\left[\frac{i - RcvBeta}{2 \times RcvGamma}\right] \qquad \text{[Eq 4-57]}$$

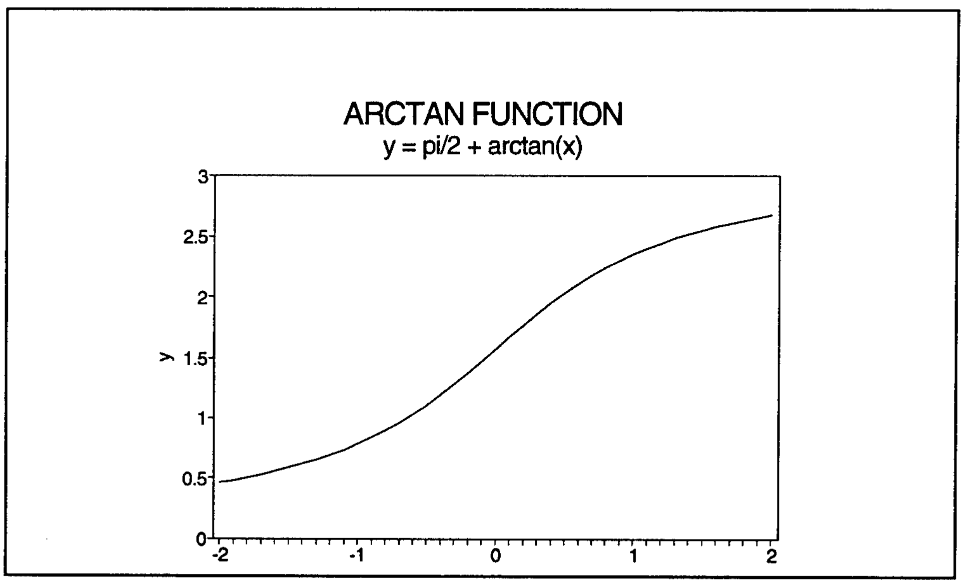

Figure 4-15. Arctan Function

The three parameters dictate recovery initiation (RcvBeta), rate of recovery (RcvGamma), and ultimate magnitude of the recovery (RcvAlpha). The parameters are functions of the ratio of spares in waiting to gross requirement, order and ship time (OST), depot repair time, and a set of user-specified constants that allows the function to be calibrated with independent data or models.

The impact of spares funding on recovery is expressed in terms of the ratio of the projected on-hand inventory to the gross requirement for the analysis year. The spares gross requirement, which reflects the value of the total required quantity of spares for the MD/MDS, is not readily available. Consequently, an approximation based on the flow of parts through depot repair is used. A certain percentage of the total inventory is repaired by the depot each year. This percentage is a function of the NRTS (not reparable this station) rate, condemnation rate, quantity per aircraft, and demand rate (repair demands per flying hour), all averaged over the MD/MDS, and annual flying hours. The ratio of the asset value to annual repair cost can then be derived from this percentage, the cost per repair, and the value per unit. As the value of this ratio (AssetToRepRatio), which would vary by MD, has not been estimated at this time, a default value of 5 is used. The gross total requirement is determined from the estimated value of the inventory plus the annual requirement for procurement of spares.

$$GrossTotReq = AssetToRepRatio \times DlvRepReq + DlvBuyReq \qquad \text{[Eq 4-58]}$$

where

AssetToRepRatio = ratio of asset value to annual repair funding

DlvRepReq = delivered spares repair requirement

DlvBuyReq = delivered spares buy requirement

The gross total funding value is equal to the gross total requirement minus the funding shortfall for the analysis year.

$$GrossTotFnd = GrossTotReq - (DlvRepReq + DlvBuyReq - DlvRepFnd - DlvBuyFnd) \qquad \text{[Eq 4-59]}$$

Other funding parameters that are assumed to impact recovery include depot maintenance and OWRM. The resulting funding and requirement values applied to the recovery function are:

$$RcvFnd = RcvSW \times GrossTotFnd + RcvOW \times OWRMFndV \qquad \text{[Eq 4-60]}$$

$$RcvReq = RcvSW \times GrossTotReq + RcvOW \times OWRMReqV \qquad \text{[Eq 4-61]}$$

where

RcvSW = POS/RSP spares funding weighting factor

RcvOW = OWRM funding weighting factor

OWRMFndV = OWRM funding

OWRMReqV = OWRM requirement

The parameter RcvAlpha is given by:

$$RcvAlpha = \frac{\frac{RcvFnd}{RcvReq} \times RcvR1}{\frac{OrderShipDys + \frac{DRepairDys}{2}}{100} + 1} \qquad \textbf{[Eq 4-62]}$$

where

OrderShipDys	= average order and ship time from depot to base (days)
DRepairDys	= average depot repair cycle time (days)
RcvR1	= calibration constant (default = 70)

The remaining two parameters are given by:

$$RcvBeta = OrderShipDys + RcvDay + RcvR2 \qquad \textbf{[Eq 4-63]}$$

$$RcvGamma = RcvR3 - \frac{RcvFnd}{RcvReq} + \frac{DRepairDys}{200} \qquad \textbf{[Eq 4-64]}$$

where

RcvR2 = calibration constant (default = 1)

RcvR3 = calibration constant (default = 5)

The values of RcvR1, RcvR2, and RcvR3 are set in the Model Constants File.

The recovery factor inserted into the supply function appears as:

$$RcvFct(i) = CumRecFct(i) \times Range \times 0.01 \qquad \textbf{[Eq 4-65]}$$

where Range is the initial value of [1-TNMCS] minus the average value of [1-TNMCS] over the previous 10 days.

Thus RcvFct represents the cumulative percentage of recovery from the degraded TNMCS value back toward the initial (peacetime) level of TNMCS once the supply system pipelines begin to refill and the unit level maintenance capability is restored. The complete supply function for day i is:

$$[1 - TNMCS(i)] = Degradation(i) + RcvFct(i) \qquad \textbf{[Eq 4-66]}$$

where

$$Degradation(i) = C + Ae^{-Bi} \qquad \text{[Eq 4-67]}$$

The relationships of these two basic functions are illustrated graphically in Figures 4-16 through 4-18. Figure 4-16 illustrates a typical degradation function with no recovery. The y-axis is the proportion of aircraft not awaiting a part, and the x-axis represents days. Figure 4-17 illustrates the same degradation curve with the recovery function added. In this illustration, all four programs that contribute to recovery are fully funded and recovery begins on R-day (Day 30). Figure 4-18 illustrates how various funding levels affect the composite [1 - TNMCS] function. Note that the funding levels affect both the underlying degradation curve and the recovery capability of the supply system.

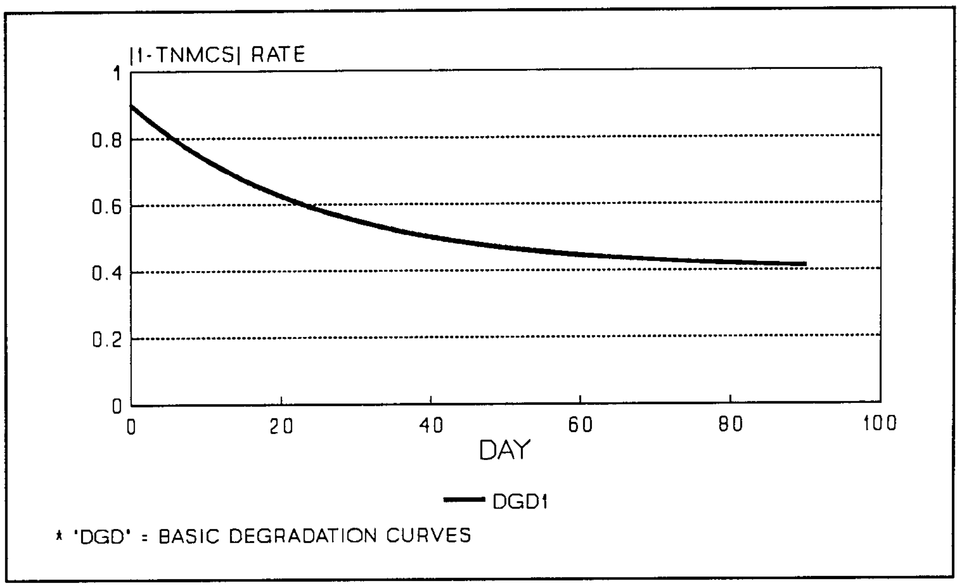

Figure 4-16. Supply Degradation (No Recovery Function)

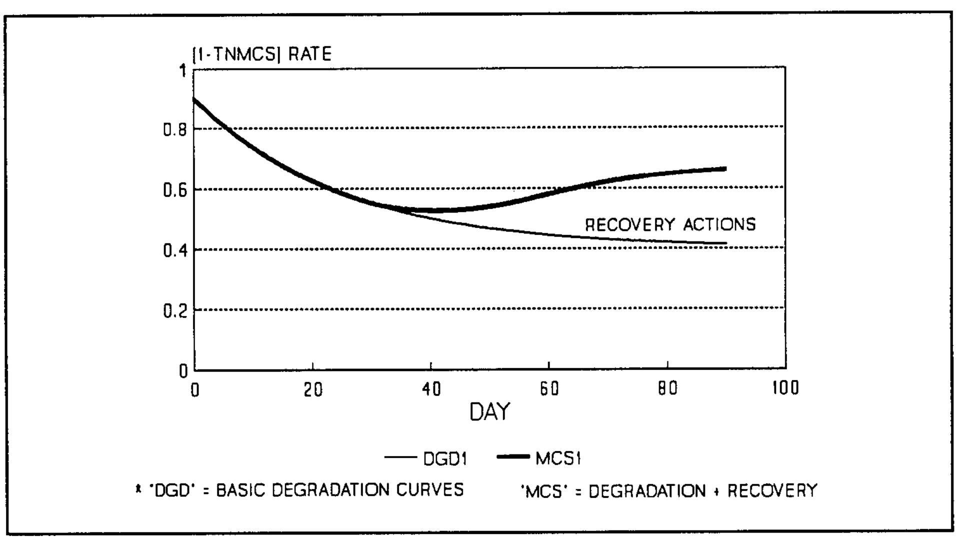

Figure 4-17. Supply Degradation (With Recovery Function)

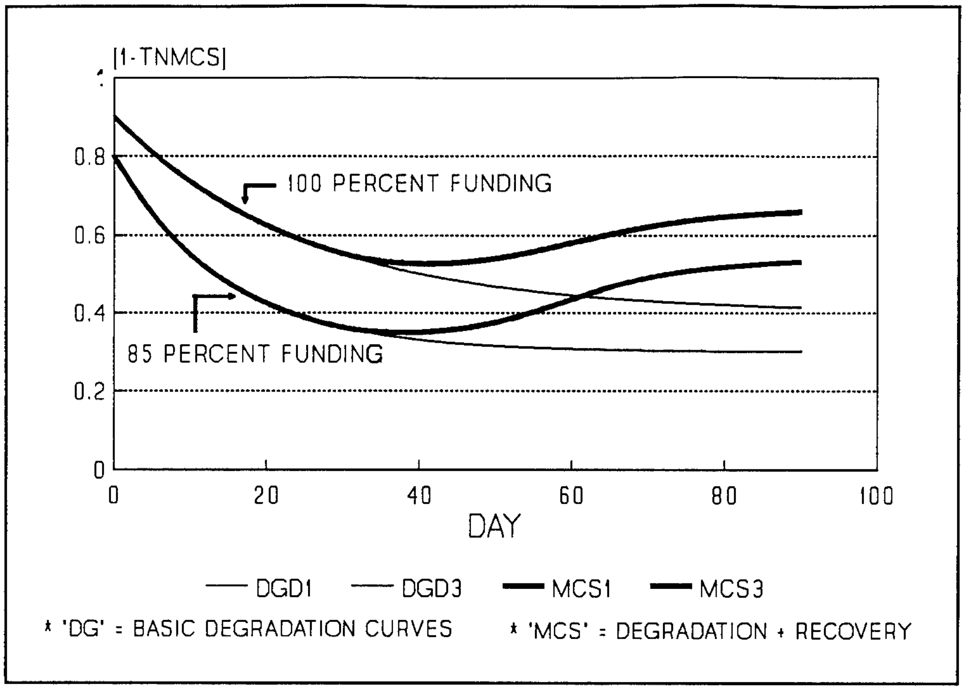

Figure 4-18. Supply Degradation (Multiple Funding Levels)

4.2.2.2.8 Maintenance Function

4.2.2.2.8.1 General Discussion

When an aircraft is not operational because it is undergoing maintenance (such as installation of a replacement part, repair or adjustment of some component, or routine scheduled inspection), it is said to be NMCM. The NMCM rate of a specific aircraft type reflects the average proportion of total possessed hours spent undergoing maintenance of some type. Such rates are measured at squadron, base, MAJCOM, and Air Force-wide levels for all major aircraft types. Additionally, period averages are used to plot trends and measure the degree of maintenance support being provided to the weapon system. Common periods are daily, weekly, monthly, quarterly, and yearly.

Weapon maintainability is a term used to express how easy it is to perform maintenance, when it is required. Many statistics are gathered on weapon systems to measure their maintainability. Mean time to repair (MTTR) is the measure of how much time, on average, it takes to repair a system when it requires maintenance. Maintenance man-hours per flying hour is a measure of how much effort is required by maintenance personnel to keep aircraft in a mission-capable state. Mean time between failures (MTBF) is the measure of how often systems on the aircraft fail, i.e., how reliable the critical components of the weapon system are. The system NMCM rate is an important indicator of both reliability and maintainability.

To a large degree, NMCM rates can be affected by a number of important resource programs. The most obvious and critical ones are as follows:

- Maintenance manpower at operating unit level.
- Quantity and status of maintenance support equipment such as test equipment, test stands, etc.
- Level of training and experience of the maintenance workforce.
- Inherent maintainability of the weapon system.
- Component reliability.
- Maintenance facilities.
- Maintenance environment (peacetime or wartime).

The challenge in developing parametric functions to estimate NMCM rates is complicated by the lack of analytical evidence that relates to resource programs. Unlike supply support, where a number of existing analytical models are accepted for resource programming purposes, modeling of maintenance support is a complex task that has largely been approached through large-scale, detailed simulation programs such as the Logistics Composite Model. Therefore, parametric estimators were developed around intuitive relationships, applied conservatively and logically, and designed to be calibrated with available peacetime data and then evaluated with wartime OPTEMPOs.

The conceptual framework for the maintenance function is that *wartime* NMCM rates will be proportional to peacetime NMCM rates and inversely proportional to the reduced number of hours available for maintenance.

There are three underlying drivers in the maintenance functions:

- System variable — While NMCM rates may vary widely across different systems, they tend to remain fairly stable in peacetime for specific weapon systems. Thus, observed steady state peacetime NMCM rates for a specific system are important parameters, given:

    -- Stability of maintenance resources
    -- Stability of OPTEMPO

- Resource levels — If resource levels (such as manpower and equipment) are reduced or efficiencies (such as changes in training levels) are reduced, maintenance actions will take longer and NMCM rates will increase.

- OPTEMPO (sortie rates) — If OPTEMPO is increased, the number of maintenance actions will increase *and* less time will be available to perform these actions; therefore, NMCM rates will increase. Sortie rates are converted to available maintenance hours per flying hour, which is then used as the independent variable in the run-time maintenance function in the models to project NMCM rates.

The basic maintenance equation adopted takes the form of:

$$Y = M \times \left[1 - \frac{N}{X}\right] \qquad \textbf{[Eq 4-68]}$$

where

- Y is the dependent variable that represents the proportion of aircraft *not* in maintenance, or [1 - NMCM].

- N is the system variable, constant for a specific weapon system, represented by the product of the current observed peacetime NMCM rate and an activity multiplier.

- M is the resource level variable, which for a given model run is determined by the manpower and equipment levels normally expressed as a percentage of requirement.

- X is the independent variable in the day-to-day segment of the model, which represents available maintenance hours per flying hour (which in turn is a function of OPTEMPO).

4.2.2.2.8.2 Behavioral Characteristics of the Maintenance Function

Where the value of M is less than or equal to 1.0 (less than or equal to 100 percent of requirement), Figure 4-19 illustrates the shape of the curve (Equation 4-68) as a function of X. The effect of various values of N is shown with multiple plots.

In this construct, N represents different values of steady-state or average peacetime NMCM rates for a weapon system. The value of X in the equation represents the daily hours available for maintenance and is determined by subtracting operating hours from 24. Thus for a given value of M and N, Y will vary as a function of operating hours. In this illustration, multiple plots are shown using different values of N to demonstrate how the steady-state maintainability of the system alters sensitivity to changes in OPTEMPO.

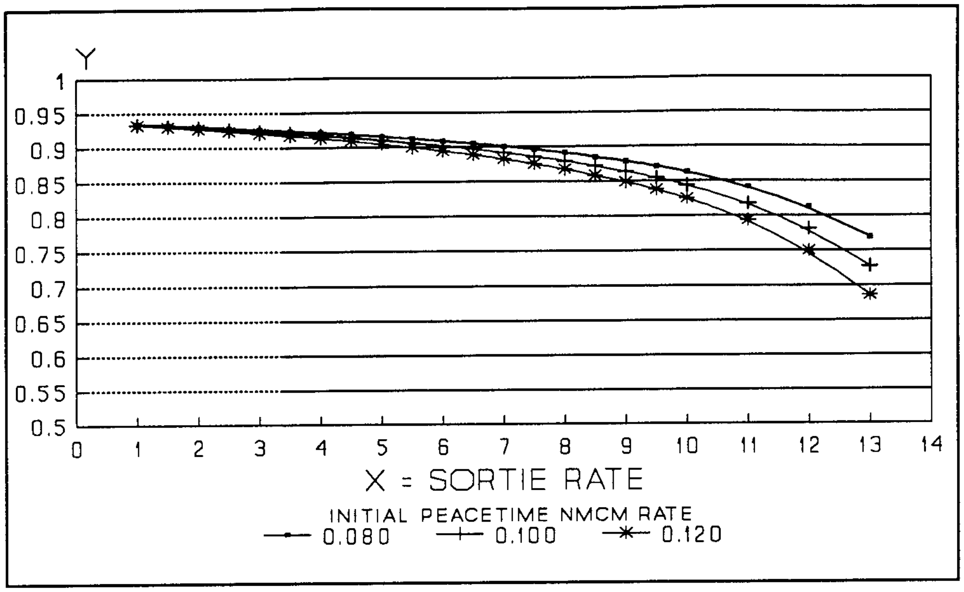

Figure 4-19. General Maintenance Function
Where Y = [1 - TNMCM] and M = 0.93

The maintenance function is illustrated in Figure 4-20. The dependent variable in the equation is [1 – NMCM]. Each of the parametric variables in the equation is identified as M with multiple subscripts. M_0 is the calibration variable.

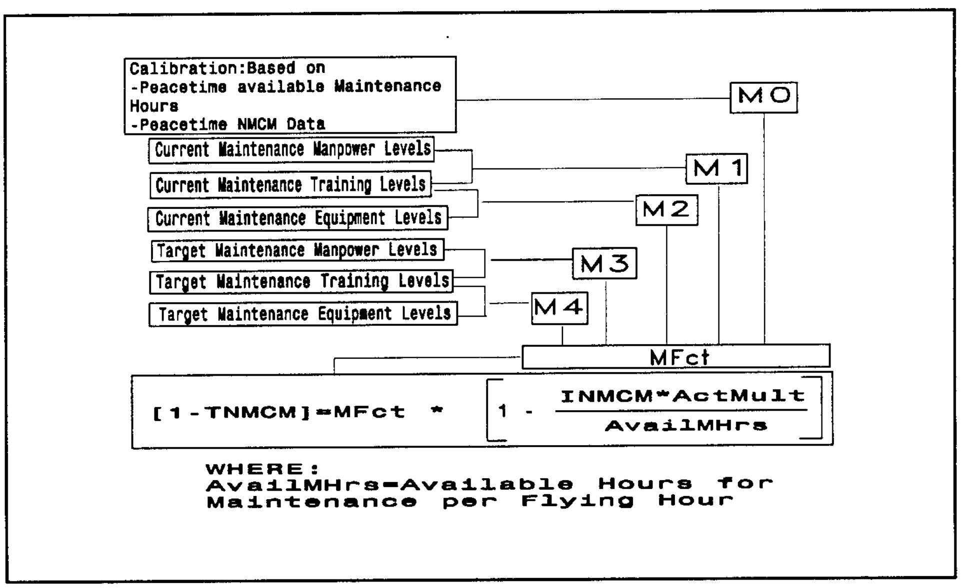

Figure 4-20. Maintenance Function Data Flow

The critical factor is peacetime (initial) NMCM rate, INMCM, based on the most recent 24 months of experience as recorded in the maintenance data collection system accessed through REMIS, coupled with the corresponding peacetime utilization rates. With this information, TLAM determines the appropriate values of

M_0. Other functions that employ nonlinear marginal return algorithms then determine the values of the remaining parametric variables, M_1, M_2, M_3, and M_4, based on resource funding.

4.2.2.2.8.3 Application in TLAM

The equation used in GPM is as follows:

$$1 - NMCM(i) = MFct \times \left[1 - \frac{INMCM\ x\ ActMult}{AvailMHrs(i)}\right] \qquad \text{[Eq 4-69]}$$

where

MFct = maintenance factor

INMCM = initial not mission capable, maintenance

NMCM (i) = not mission capable, maintenance on day i

The activity multiplier (ActMult) is computed as follows:

$$ActMult = \frac{SurgSR - CurPeaceSR}{CurPeaceSR} \qquad \text{[Eq 4-70]}$$

ActMult is constrained to be not less than 1 and not greater than 2.5.

The independent variable is AvailMHrs(i), defined as available maintenance hours per flying hour for a specified level of activity on day i. Note that this is not the same as maintenance man-hours per flying hour; it is an expression of the number of hours an aircraft is available to the maintenance organization to perform maintenance, if required. The value of this variable is inversely proportional to the sortie rate or utilization rate demanded of the system. The equation is as follows:

$$AvailMHrs(i) = \frac{24 - (FlgtHrsDay + SR \times SServHrs)}{FlgtHrsDay} \qquad \text{[Eq 4-71]}$$

where

SR = Average sortie rate over a specified period (default=10 days)

FlgtHrsDay = Average flying hours per aircraft per day over same period

SServHrs = Service hours per sortie

Figure 4-21 illustrates the relationship between flying hours per day, and available maintenance hours per flying hour (AvailMHrs).

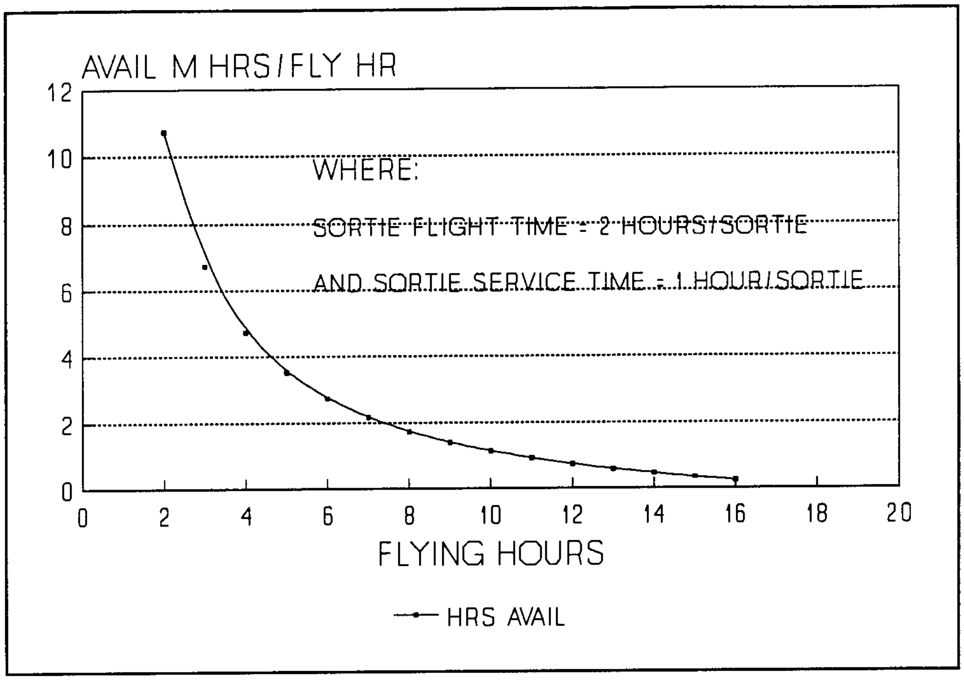

Figure 4-21. Available Maintenance Hours Per Flying Hours Increase

The variable MFct in the equation represents the combination of parametric variables through which logistics programs are captured. The value of MFct is a composite variable computed from the following more specific variables.

- M_0 is a calibration variable.
- M_1 is a function of current maintenance manpower and training.
- M_2 is a function of current percentage of maintenance equipment on hand and training.
- M_3 is a function of maintenance manpower percentage and training level projected for target year.
- M_4 is a function of on-hand equipment percentages and training projected for target year.

The current year corresponds to the current fiscal year and the target year to the assessment year. For example, during FY94, one may be assessing the weapon system for FY97. The current and target parameter values are taken from the databases for the respective years.

The value of M_0 is determined by current peacetime values:

$$M_0 = \frac{1 - INMCM}{1 - \dfrac{INMCM \times ActMult}{PeaceAvailMHrs}} \quad \textbf{[Eq 4-72]}$$

and

$$MFct = M_0 \left(\frac{M_3 + M_4}{M_1 + M_2} \right) \quad \textbf{[Eq 4-73]}$$

PeaceAvailMHrs is computed as shown in Equation 4-71 with the peacetime sortie rates and flying hours per day used in place of the wartime values.

Computing the Values of M_1 thru M_4 — These are the key maintenance resource variables in GPM as defined above. All are evaluated as ≤ 1.0. A value of 1.0 represents maximum contribution to the maintenance function; values less than 1.0 represent some level of resource-limiting degradation. The pacing resources are manpower (M1 and M3) and equipment (M2 and M4), but each is computed using a decreasing nonlinear marginal return (NLMR) function, which is modified by several other factors described next. The general form of this equation is:

$$NLMR = CAP \times \left(1.0 - (1.0 - RsrcFct)^{(CurveFct \times ModFct \times Wght)}\right) \quad \textbf{[Eq 4-74]}$$

where

$$CAP = 1.0 \textit{ if training percentage} \geq 50\% \quad \textbf{[Eq 4-75]}$$

$$or = \frac{2.0 \times percent}{50 + percent}, \textit{ if percent is} < 50\%$$

RsrcFct = percentage of maintenance manning or equipment (decimal value)

CurveFct = training percentage (decimal value)

ModFct = system maintainability factor (between 1.5 and 2.5)

Wght = resource weight factor (1.0 or 0.9)

A graphical representation of this function is illustrated in Figure 4-22. This figure shows a linear marginal return curve for reference purposes only. The bowed or nonlinear marginal return curve is characteristic of the treatment of maintenance resources in the model. In this figure, the cross hair shows a returned value of 0.87 for a resource percentage of 70. Note that as RsrcFct (resource percentage of requirement) approaches 1.0, added resources have a decreasing effect on the computed parametric variable.

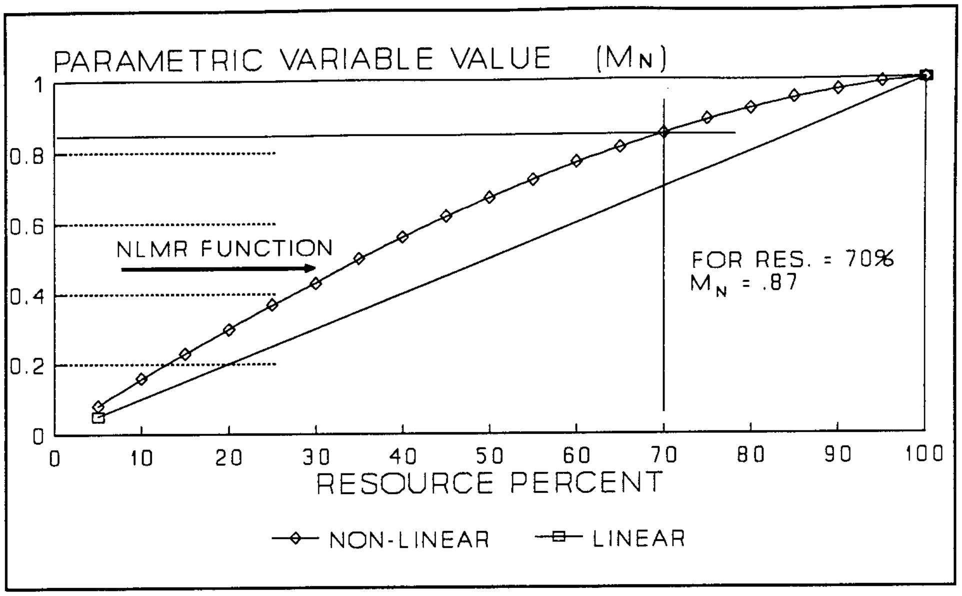

Figure 4-22. Maintenance Resource Percentage versus Parametric Factors

The following paragraphs describe how each of the additional variables interacts in this function to modify returned parametric values.

Training level of direct maintenance personnel (CurveFct) — Training level is represented by two variables: CurMTrain for current year and TrgMTrain projected for the year under consideration. The value for each of these variables is defined by the percentage of the base-level maintenance workforce trained to the authorized skill level. CurMTrain is used in the computation of M_1 and M_2, and therefore, it is incorporated in the computation of M_0, the calibration variable. Training for the target year is then used in the computation of values for M_3 and M_4. The assumption underlying the use of training level to modify the parameter values is that higher training levels will partially mitigate resource shortfalls (or conversely will compound problems when training levels are low).

Figure 4-23 illustrates the effect of different levels of training within the maintenance organization. Note the differences in returned parameter values at a resource level of 75 percent. The upper curve (80 percent trained) would return a value of about 0.94 for the parameter associated with this resource; at 50 percent training, the same 75 percent resourcing would return a parameter value of about 0.83. Note also that training levels of below 50 percent always return a parameter value of less than 1.0, even with full resources.

Weapon System Maintainability Factor (ModFct) — A second major consideration is the inherent maintainability of the system. Three values may be selected for this variable corresponding with easy, moderate, or difficult to maintain. The related values used in the NLMR function are 2.5, 2.0, and 1.5,

respectively. These factors are contained in the Model Constants File. The effect of this variable is illustrated in Figure 4-24. Note that higher maintainability levels partially mitigate resource shortages by returning a greater value for the parametric variable associated with that particular resource.

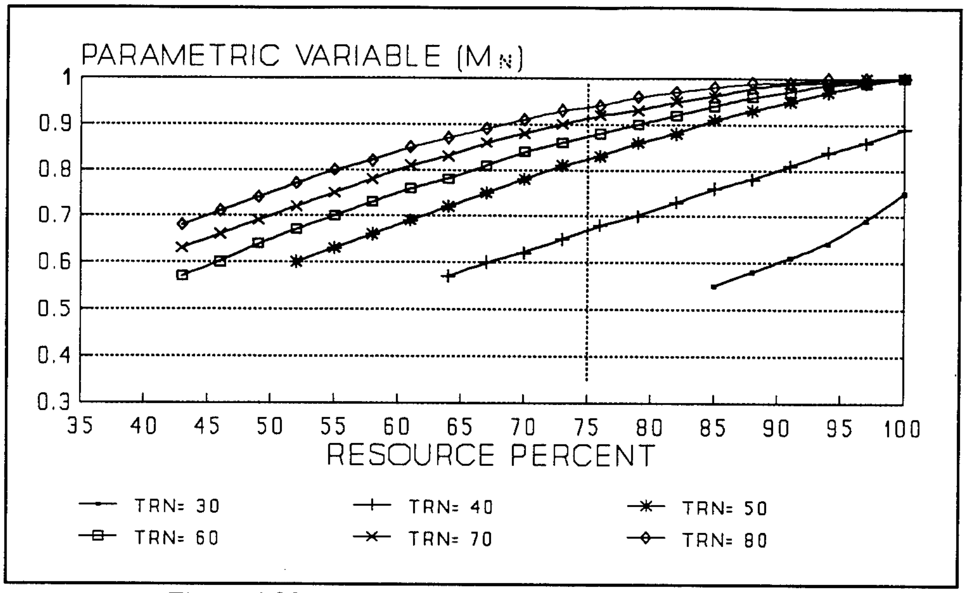

Figure 4-23. Maintenance Resource Percentage versus Parametric Factors (With Variable Training Percentage)

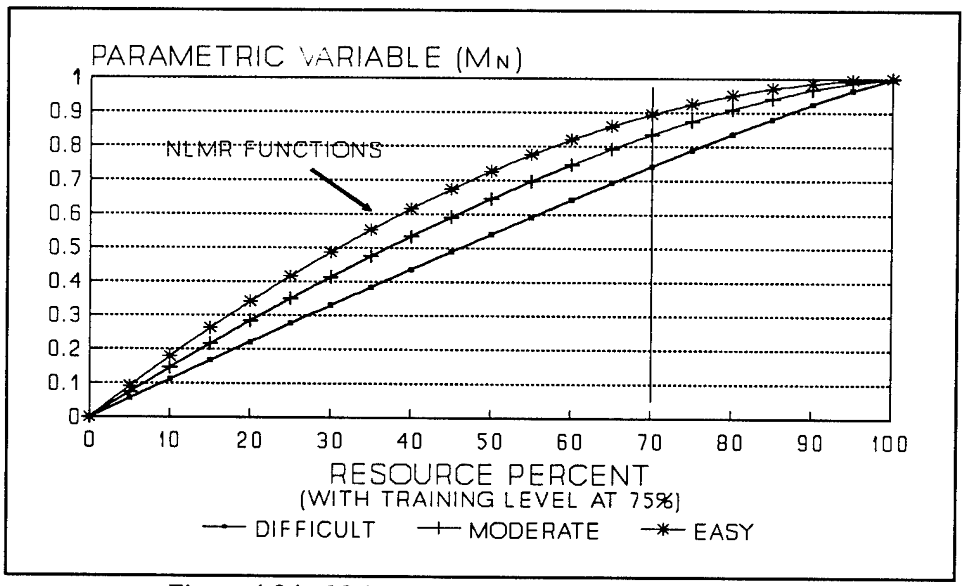

Figure 4-24. Maintenance Resource Percentage versus Parametric Factors (Effect of Maintainability Factor)

Resource Weight Factors (Wght) — Finally, manpower and equipment factors are weighted differently, represented in the computations as a variable called Wght. Manpower levels are considered more important than equipment levels. The values for Wght for manpower and equipment computations are 0.9 and 1.0, respectively. The lower value for manpower computations has the effect of flattening the NLMR curve and

suppressing the values for M_1 and M_3. These lower values tend to dominate the computation for NMCM, since the average and the manpower and equipment parameters is used in the equation for MFct (Equation 4-73). This effect is illustrated in Figure 4-25.

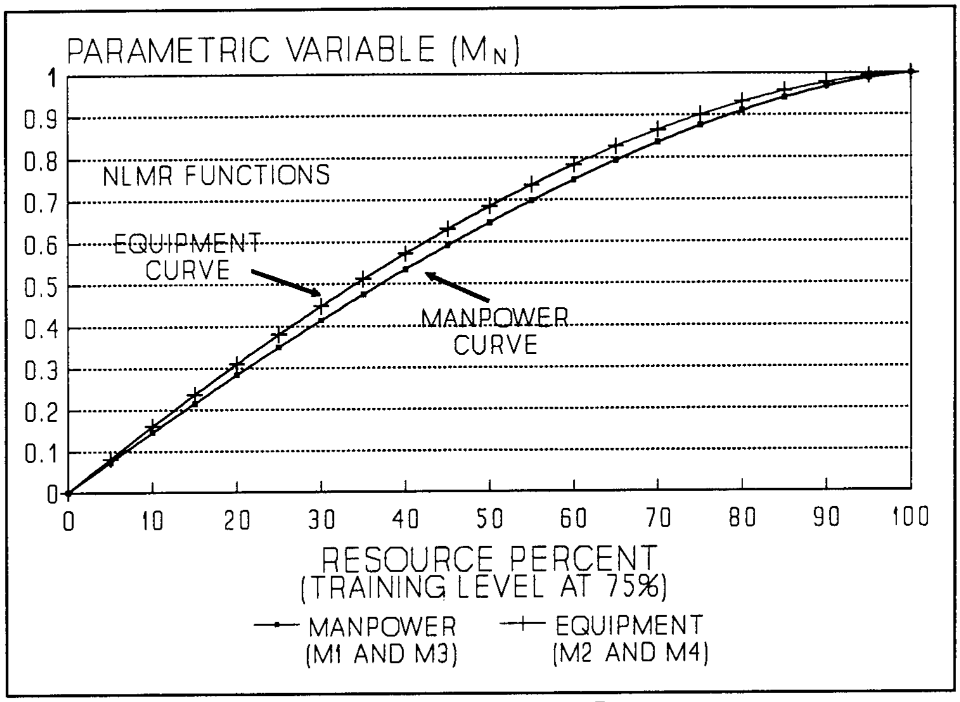

Figure 4-25. Maintenance Resource Percentage versus Parametric Factors (Manpower versus Equipment)

For all four parametric variables, then, the computational equation is the same (Equation 4-74), but the returned parametric variable values are different, depending on the resource type and level of funding. After the values of these variables are determined, MFct is calculated (using Equation 4-73) and inserted into the day-to-day function for NMCM (Equation 4-69).

For cases where the average wartime sortie rate is less than the peacetime rate, a linear equation is used in place of Equation 4-69. This linear equation allows the NMCM rate to approach zero as the average wartime sortie rate approaches zero. The equation parameters are based on the target peacetime NMCM and sortie rates. Target peacetime rates, relating to the period to which the analysis applies, are differentiated from current rates in the input data file. The latter are used for the calibration parameters while the former are used in the computation of wartime TNMCS and NMCM rates.

A target NMCM rate is computed by the following:

$$TgtNMCM = 1 - MFct\left(\frac{1 - INMCM\ x\ ActMult}{TgtAvailMHrs}\right) \qquad \text{[Eq 4-76]}$$

where TgtAvailMHrs is computed as in Equation 4-71 with the sortie rate and flying hours per day equal to the target peacetime values.

Intercept and slope parameters for the linear equation are given by:

$$Y_{int} = 1 - 0.2 \times TgtNMCM \qquad \text{[Eq 4-77]}$$

$$Slope = \frac{1 - TgtNMCM - Y_{int}}{TgtPeaceSR} \qquad \text{[Eq 4-78]}$$

Finally, the NMCM rate for day i is obtained from the parameters and the average wartime sortie rate.

$$1 - NMCM(i) = Y_{int} + Slope \times AvgSR \qquad \text{[Eq 4-79]}$$

The Moving Average Independent Variable — As described earlier, the independent variable in the NMCM function is available maintenance hours per flying hour. As the model computes NMCM values for each day, the flying time and mission ground time are computed and then used to determine how much time is available for maintenance. However, maintenance problems do not normally generate overnight and direct use of this value in the run-time function would drive instantaneous changes in NMCM rates. Therefore, a moving average technique is employed to soften the effects of wide changes in OPTEMPO.

In TLAM, a 10-day moving average is used in the computation formulas, which is the equivalent of saying that the full effect on NMCM rates of higher system sortie rates will not be felt for about 10 days. Over some period of time, maintenance backlogs will grow, but with only a gradual effect on availability of aircraft to perform the mission. The moving average function is seeded with 10 days at peacetime rates. The parameter representing the number of moving average days is contained in the Model Constants File, allowing modification if future experience should provide indications that NMCM rates are more or less sensitive to changes in OPTEMPO.

4.2.2.2.9 MC Rate Equation

As noted above, the MC rate is a function of the NMCM and TNMCS rates.

$$MC = 1 - TNMCS - NMCM \quad \text{[Eq 4-80]}$$

4.2.2.3 Output Products

The output data arrays can be stored in ASCII format for easy access and creation of display templates using Harvard Graphics software. An internal graphics feature enables the user to review the output data without exiting TLAM. The output arrays also include a header with a prespecified title, a subtitle, and legend information that is used when creating templates.

WINLAM has a feature in the output data structure that will allow the user to compare two runs of the model. By accessing this feature, the user may provide different input data, store the results in comparison arrays, and call up specially constructed graphics for easy comparison of results using the internal graphics feature or Harvard Graphics.

4.2.3 GLOBAL REACH MODULE SYSTEM FUNCTIONS

The Global Reach Module, also known as the Airlift Systems Assessment Model (ALAM), addresses the wartime operations of airlift aircraft. While ALAM and TLAM share the same conceptual and mathematical approach, they differ somewhat in their scope. ALAM is tailored to UTE rate and contains an aircrew function that constrains the UTE rate and a cargo-delivered function that determines the tons of cargo moved. However, like TLAM, ALAM can be described as a series of static and dynamic analytical processes that combine to provide UTE rate information. As in TLAM, the static routines provide the calibration of a series of parametric variables that are then used in the form of parametric equations in the dynamic routines, which are evaluated on a day-to-day basis.

The inputs for the static routines that define the values of specific parametric variables are related to specific independent resource funding levels for logistics programs. If funding changes are considered, the static routines provide rapid recomputation of these variables for the dynamic portion of ALAM.

When a weapon system database is selected, all parametric variables are computed and made available to the dynamic routines, which can be run for any set of required UTE rates for any period of time up to 180 days.

4.2.3.1 Dynamic Segment

The dynamic segment of the model shown in Figure 4-26 illustrates how the model operates.

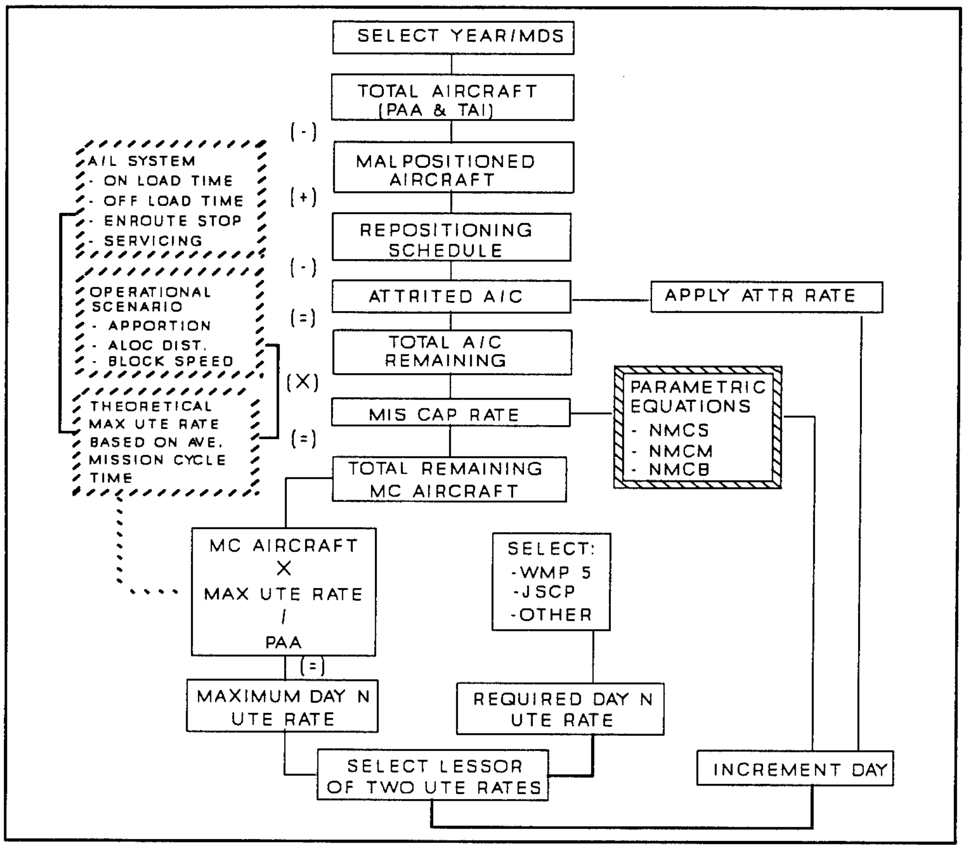

Figure 4-26. GRM (ALAM) Dynamic Segment

Sequentially, the process is as follows:

- Initialization of all parameters is accomplished at the beginning of the run. All logistic funding parameters are computed and initial maximum UTE rate is determined based on the input values of the airlift system and the operational scenario variables shown on the left side of Figure 4-26.

- The model proceeds to loop through the required number of days, performing the computations shown in the figure. As illustrated, the key UTE rate computation occurs when the maximum

UTE rate for day i is compared with the required rate specified in the input parameters. The lesser value is selected and the result is stored in a daily UTE rate file.

- After each day of activity, the parametric equations are evaluated to determine the projected MC rate for the next day.

- If it was determined in advance to include attrition, total aircraft remaining is also decremented prior to applying the computed MC rate. Attrition can be turned off or run at any desired level.

In addition to daily UTE rate, other information is also computed and stored on a daily basis. This information is available through various output routines.

4.2.3.2 Aircraft Attrition

The remaining number of aircraft for each day, RemAcft(i), is determined by taking into account aircraft attrition, repositioned aircraft, and aircraft returning to the active fleet from the depots. Aircraft attrition is determined from the attrition rate.

$$AttrAcft(i) = TotHrsFlwn(i) \times AttrR \qquad \text{[Eq 4-81]}$$

where

AttrAcft(i) = number of aircraft lost to attrition through day i

TotHrsFlown = total flying hours through day i

AttrR = attrition rate per flying hour

4.2.3.3 Repositioned Aircraft

At the beginning of deployment, a number of aircraft may be required to fly to their home bases before initiating their missions. It is assumed that these aircraft may take from 1 to 3 days to reposition themselves. The user specifies the number of such aircraft and the proportion repositioned in 1, 2, and 3 days after the first warning. The number of warning days is also user-specified. Out-of-position aircraft are subtracted from the total aircraft prior to the first day of the combat and added back in during the first 3 days (maximum) of the combat period. The number of out-of-position aircraft added to the active fleet on day i is given by:

$$\begin{gathered} \text{if } \leq WarnDys \\ NumRepos = MACRepos \times MACReposDay\ (i - WarnDys) \\ \text{else} \\ NumRepos = 0 \end{gathered} \qquad \text{[Eq 4-82]}$$

where

WarnDys = number of warning days

NumRepos = number of out-of-position aircraft on day i

MACRepos = number of aircraft to be repositioned

MACReposDay (i - WarnDys) = proportion of aircraft to be repositioned on day i - WarnDys

4.2.3.4 Depot Aircraft

The model provides for a user-specified number of aircraft being in the depot at the beginning of the period. The aircraft are returned to the active fleet at a rate defined by a curve of the form shown in Figure 4-27.

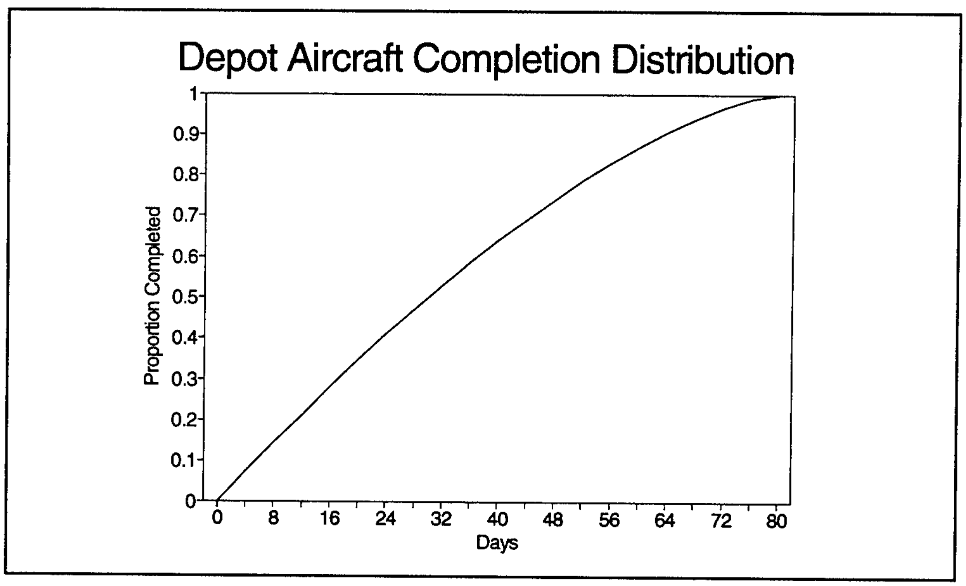

Figure 4-27. Depot Completion Time Distribution

It is assumed that the depot begins moving aircraft out of the depot at the first warning of hostilities, with no aircraft entering the depot after that date. The equation for the number of returns on day i, i + WarnDys < DepCmpDays, is:

$$CumDepRtns(i) = DepAcft \times \left(1 - \left(1 - \frac{d}{DepCmplDays}\right)^{RtrnsFctr}\right) \qquad \text{[Eq 4-83]}$$

where

WarnDys = number of warning days before wartime employment

d = i + WarnDys

DepAcft = average number of aircraft in depot maintenance during peacetime

CumDepRtns(i) = proportion of depot aircraft completed by day i

DepCmplDays = number of days to complete all aircraft in the depot (user specified)

RtnsFctr = factor specifying the return rate (see below)

If i + WarnDys > DepCmplDays, then all aircraft have been returned from the depot:

$$CumDepRtns(i) = DepAcft \qquad \text{[Eq 4-84]}$$

The parameter RtnsFctr is determined from user specified values of the number of days from the initial warning to complete depot maintenance on 100 percent of the aircraft (DepCmplDays100) and the number of days to complete 50 percent of the aircraft (DepCmplDays50).

$$RtnsFctr = \frac{\ln(0.5)}{\ln\left(1 - \frac{DepRtns50}{DepCmplDays100}\right)} \qquad \text{[Eq 4-85]}$$

4.2.3.5 Remaining Aircraft

The number of remaining aircraft on day *i* is based on the initial number of aircraft less those lost to attrition plus repositioned aircraft (for the first three days) and aircraft returning from the depot.

$$RemAcft\ (i) = RemTAI - AttrAcft(i) + NumRepos + DepRtns \qquad \text{[Eq 4-86]}$$

4.2.3.6 Parametric Equations

As in TLAM, the ALAM model can be thought of in terms of two segments: calibration and dynamic, or day-to-day. The calibration segment, consisting of the ALC and Calibration procedures, generates the parameters used to compute daily MC rates, UTE rates, and amount of cargo delivered in the dynamic segment. The ALC procedure computes the allowable cabin load (AllowableCabLoad) for the aircraft based on distances, enroute stops, and maximum aircraft capacities. This parameter is used in the computation of million ton miles

per day delivered by the aircraft. The Calibration procedure computes the A, B, and C parameters used in the exponential equation for TNMCS; the M and ActMult parameters used in the computation of NMCM; and RcvAlpha, RcvBeta, and RcvGamma used in the recovery function. The equations for these parameters are virtually identical to the formulations in TLAM with UTE rates replacing sortie rates in the computation of B_0, C_0, and ActMult. The TNMCS and NMCM computations are also identical. Consequently, the equations will not be repeated here. Unlike TLAM, ALAM always uses a single DSO, nominally for a 30-day period, although this parameter can be changed by the System Administrator.

ALAM includes the concept of air lines of communication (ALOC), which represent regions, such as a theaters, to which materiel and personnel are transported. Input parameters such as flying distances, enroute stops, cabin loads, service and loading hours, and required UTE rates are specified by ALOC. Derived parameters such as mission hours per day, ground hours per day, required UTE rate, allowable cabin load, block speed, and productivity are averaged over the ALOCs, weighted by the relative number of aircraft per ALOC. The resulting MC and UTE rates and delivered ton-miles then represent averages across ALOCs. Thus, unlike TLAM, ALAM operates in terms of a single composite theater whose parameters represent weighted averages of the individual ALOC values.

4.2.3.7 Required UTE Rates

The required daily UTE rates are derived by computing the weighted averages of the ALOC UTE rates, which are specified by user-defined periods and by ALOC. Prior to C-Day, the aircraft fly at the peacetime rate. The weighting factor is the proportion of the number of aircraft in each ALOC, which can vary by day at the user's discretion.

$$ReqUTE(i) = \sum_{a} UTE(i,a) \times AppmtbyALOC(i,a) \qquad \textbf{[Eq 4-87]}$$

where

ApptmtByALOC(i,a) = proportion of aircraft in ALOC a on day i

UTE(i,a) = UTE rate for ALOC a on day i.

4.2.3.8 Effective UTE Rates

The effective (flown) UTE rate for Day i is equal to the minimum of the required UTE rate and the maximum UTE rate. The latter is constrained only by the logistics resources and is based on a computed theoretical maximum UTE rate (ThMaxUTE), and the MC rate, adjusted by the ratio of remaining TAI (after attrition)

to PAA. The theoretical maximum UTE rate is determined by the average time available to fly the daily missions, which is a function of the average mission flying hours and average ground hours per mission.

The average ground hours per mission for theater a is determined from the on-load, off-load, and service times as well as the support times during the outbound and the return stages of the mission.

$$AvgGrndHrsPerMssn(a) = ServHrs(a) + OnLoadHrs(a) + OffLoadHrs(a) + EnrouteSupportHrs(a) \times [NumEnrouteStops(a) + NumRecoveryStops(a)] \quad \text{[Eq 4-88]}$$

where

ServHrs(a) = service hours per mission for ALOC a

OnLoad(a) = on-load hours per mission for ALOC a

OffLoad(a) = off-load hours per mission for ALOC a

EnrouteSupportHrs(a) = support hours per enroute (outbound or return) stop for ALOC a

NumEnrouteStops(a) = number of stops on the outbound stage of the mission for ALOC a

NumRecoveryStops(a) = number of stops on the return stage of the mission for ALOC a

The average mission ground hours over all ALOCs, computed for Day i, is:

$$GrndHrsMssn = \sum_{a} AvgGrndHrsPrMssn(a) \times AppmtbyALOC(i,a) \quad \text{[Eq 4-89]}$$

Average mission flight time for an ALOC is estimated from the distance, speed, and number of takeoffs/landings. Each stop, as well as the initial take-off and final landing, is assumed to add 25 minutes to the mission.

$$MssnFT(a) = \frac{2 \times ChannelDist(a)}{TrueAirSpeed} + \frac{25}{60}[NumEnrouteStops(a) + NumRecoveryStops(a) + 2] \quad \text{[Eq 4-90]}$$

where

ChannelDist(a) = average distance from the flight origin to ALOC a

TrueAirSpeed = average air speed

The average mission flight time over all ALOCs, compute for Day i, is:

$$AvgMssnFT = \sum_{a} MssnFT(a) \times AppmtbyALOC(i,a) \quad \text{[Eq 4-91]}$$

The theoretical maximum UTE rate over a 24-hour period, for Day i, is estimated from ratio of flying hours to total cycle hours per mission.

$$ThMaxUTE(i) = \frac{24 \times AvgMssnFT}{AvgMssnFT + GrndHrsMssn} \qquad \text{[Eq 4-92]}$$

The maximum UTE rate taking into the account logistics constraints implicit in the MC rate is:

$$MaxUTE(i) = MC(i) \times ThMaxUTE(i) \frac{RemTAI}{PAA} \qquad \text{[Eq 4-93]}$$

The ratio RemTAI/PAA is necessary because the MC rate is based on PAA while the UTE rates are based on total aircraft.

The effective UTE rate is simply the minimum of the required rate and the maximum rate.

$$EffUTE(i) = \min\ [MaxUTE(i),\ ReqUTE(i)] \qquad \text{[Eq 4-94]}$$

4.2.3.9 Allowable Cabin Load Computation

The allowable cabin load for each ALOC used in the computation of delivered tonnage is computed in the procedure CalcALC prior to the initiation of the day-to-day process. The computation depends upon the distance of the critical leg of a mission, which is defined in terms of the one-way distance from the origin to the ALOC and the number of enroute stops. The number of enroute stops (stops on the outbound portion of the mission) is an input parameter, specified by ALOC. The minimum number of stops is:

$$MinEnrouteStops = \frac{ChannelDist(a)}{MaxFerryDistance \times 0.65} \qquad \text{[Eq 4-95]}$$

where

ChannelDist(a) = one-way distance from origin to ALOC a

MaxFerryDistance = maximum distance flown without a stop

The number of enroute stops for ALOC a, NumEnrouteStops(a), is equal to the maximum of MinEnrouteStops and the input value of NumEnrouteStops(a). The minimum number of recovery stops, used for the ground hour computation given below, is:

$$MinRecoveryStops = \frac{ChannelDist(a)}{MaxFerryDistance} \qquad \text{[Eq 4-96]}$$

The number of recovery stops for ALOC a, NumRecoveryStops(a), is equal to the maximum of MinRecoveryStops and the input value of NumRecoveryStops(a).

Next, an estimated value of the critical leg distance is computed from the channel distance and number of enroute stops.

$$\begin{aligned} EstCritLegDist(a) &= \frac{ChannelDist(a)}{NumEnrouteStops(a)\ +1}\ 1.05 \qquad \textit{for } NumEnrouteStops(a) \geq 1 \\ EstCritLegDist(a) &= ChannelDist(a) \qquad \textit{for } NumEnrouteStops(a) < 1 \end{aligned} \qquad \text{[Eq 4-97]}$$

The final critical leg distance for ALOC a is obtained by first determining the maximum of EstCritLegDist(a) and CriticalLegDist[a] (input value) and then taking the minimum of this result and ChannelDist(a).

$$CritLegDist(a) = \min[ChannelDist(a),\ \max[CriticalLegDist(a),\ EstCritLegDist(a)]] \qquad \text{[Eq 4-98]}$$

This value is used in a linear equation to estimate the allowable cabin load. The slope of the equation is determined from two pairs of input parameters for cabin loads and distances.

$$slopeacl = \frac{ACL2\ -\ MaxACL}{Dist2\ -\ DistAtMax} \qquad \text{[Eq 4-99]}$$

where

MaxACL	= maximum allowable cabin load
ACL2	= alternate allowable cabin load
DistAtMax	= distance corresponding to MaxACL
Dist2	= distance corresponding to ACL2

Finally, the allowable cabin load for ALOC a is obtained by substituting CriticalLegDist(a) in the linear equation.

$$AllowableCabLoad(a) = MaxACL - slopeacl \times [DistAtMax - CritLegDist(a)] \quad \text{for } CritLegDist(a) > DistAtMax \qquad \text{[Eq 4-100]}$$

$$AllowableCabLoad(a) = MaxACL \qquad \text{for } CritLegDist(a) \leq DistAtMax$$

4.2.3.10 Tons of Cargo Delivered

To provide the user with information on airlift capability corresponding to the calculated UTE rates, estimations of the amount of cargo delivered and ton-miles per are included in the model. Both variables use allowable cabin load and productivity factors. The productivity factor is a ratio that accounts for the aircraft not being fully loaded on some of the legs of a mission. For example, the return leg is normally empty, and on the outbound leg an aircraft may be required to fly empty to a particular load point. Each of these parameters is specified by ALOC and a weighted average is computed. The average block speed, allowable cabin load, and productivity factors are computed as follows:

$$WBlockSpeed = \sum_a \frac{2 \times ChannelDist(a) \times AppmtbyALOC(i,a)}{MssnFT(a) \times PAA} \qquad \text{[Eq 4-101]}$$

$$WAllowableCabLoad = \sum_a AllowableCabLoad(a) \times AppmtByALOC(i,a)$$

$$WProdFct = \sum_a ProdFct(a) \times AppmtByALOC(i,a)$$

The total number of missions flown per day is used for the computation of the delivered tonnage.

$$TotMssnPerDay = \frac{EffUTE \times PAA}{AvgMssnFT} \qquad \text{[Eq 4-102]}$$

Million ton-miles per day is computed by multiplying miles flown per day and tons carried. The former is the product of effective UTE rate (flying hours per day per aircraft), number of aircraft, and block speed (miles per hour), while the latter is the product of capacity (cabin load) and productivity.

$$MTMsPerDay(i) = PAA \times EffUTE(i) \times WBlockSpeed \times WAllowableCabLoad \times WProdFct \times \frac{1}{1000000}$$

[Eq 4-103]

The number of tons transported determined from the number of missions per day and the average tons carried per mission.

$$TonsDelivPerDay = TotMssnPerDay \times WAllowableCabLoad \times WProdFct \times 2 \quad \textbf{[Eq 4-104]}$$

4.2.3.11 Aircrew Constraints

In addition to the supply and maintenance functions which are shared with GPM, a capability was added to GRM that allows the user to estimate the effects of aircrew personnel costs on daily UTE rates. The user specifies the crew ratio (aircrew personnel per aircraft), crew availability ratio, maximum crew duty hours per day, minimum crew rest period, and 30- and 90-day flying hour limits. In addition, an initial period of unconstrained flying hours can be specified. After the initial unconstrained period, the maximum daily flying hours per crew is estimated from the flying hours and days remaining in the 30-day period. The crew-constrained UTE rate is then computed from the maximum hours per crew, crew ratio, and crew availability. The result is adjusted by a factor that reflects the fact that at a given time a crew may be available at one location while the aircraft is at another. After the 30-day period has elapsed, the 90-day constraint is applied in the same manner. The actual flown UTE rate is then set equal to the minimum of the crew-constrained UTE rate and the logistics-constrained rate.

During an initial period specified by the user, nominally 15 days, maximum flying hours per crew (CRMaxHrs) are constrained only by the duty day and rest time cycle, which dictate the limits on the proportion of the day available for flying. Thus, during this period, CRMaxHrs equals the minimum of the following computation and 24 hours.

$$CRMaxHrs = \left(\frac{CRDutyDay}{CRDutyDay + CRRestPer}\right) \times 24.0 \quad \textbf{[Eq 4-105]}$$

where

CRDutyDay = maximum number of hours per day

CRRestPer = minimum number of hours between duty periods

During the next 30 days, the maximum hours are constrained by the total allowable flying hours over the period. To determine this constraint during the day-by-day computation, the period is divided into segments of five days. At the end of each segment, the maximum hours per crew is determined from the number of flying hours remaining within the limit and the number of days remaining.

$$CRMaxHrs = \left(\frac{CRLim30 - CRCumHrs30(i)}{DaysRem(i)}\right) \qquad \text{[Eq 4-106]}$$

where

CRLim30 = 30-day crew flying hour limit

CrCumHrs30 = cumulative crew flying hours to the beginning of the segment containing Day i

DaysRem(i) = days remaining in the 30-day period from the beginning of the segment containing Day i

For the next 60 days, the 90-day crew flying hour constraint must be considered. The computation for this period is identical to the 30-day period, with the 90-day crew hour limit and 90-day cumulative hours substituted for the 30-day parameters. The nominal length of the unconstrained period is 15 days. In this case, the 30-day period coincides with the last portion of the 45-day surge period. After the 90-day period is over, the daily maximum is determined simply from the 90-day limit.

$$CRMaxHrs = \left(\frac{CRLim90}{90}\right) \qquad \text{[Eq 4-107]}$$

The aircrew constrained UTE rate for Day i is given by:

$$CRUTE(i) = CRRatio \times CRAvail \times CRMAtDgd \times CRMaxHrs \qquad \text{[Eq 4-108]}$$

where

CRRatio = crew ratio

CRAvail = crew availability

CRMatDgd= material degradation factor

The degradation factor is determined from the UTE rate constrained by maintenance and supply factors, MaxUTE(i). A relative change in the aircraft available to accomplish the missions from one day to the next implies a potential misfit in assigning crews to aircraft, which is reflected in the degradation factor.

$$CRMatDgd = 1 - ABS\left(\frac{MaxUTE(i) - MaxUTE(i-1)}{MaxUTE(i)}\right) \qquad \text{[Eq 4-109]}$$

where

ABS (x) = absolute value of x

Aircrew and supply/maintenance constrained UTE rates are shown in Figure 4-28, which illustrates how crew constraints interact with logistic constraints in ALAM. UTE rate is constrained by logistics for the first 15 days. At Day 16 (when the 30-day limit is applied), a minor crew constraint is encountered. However, as logistic resources begin to degrade, they again become the constraining factor on about Day 24. While UTE rate is constrained by logistics, GRM preserves crew hours, and from Day 24 to Day 45 the crew constraint level improves. Finally, on Day 46, the 90-day crew limit is applied and aircrews again become the limiting factor.

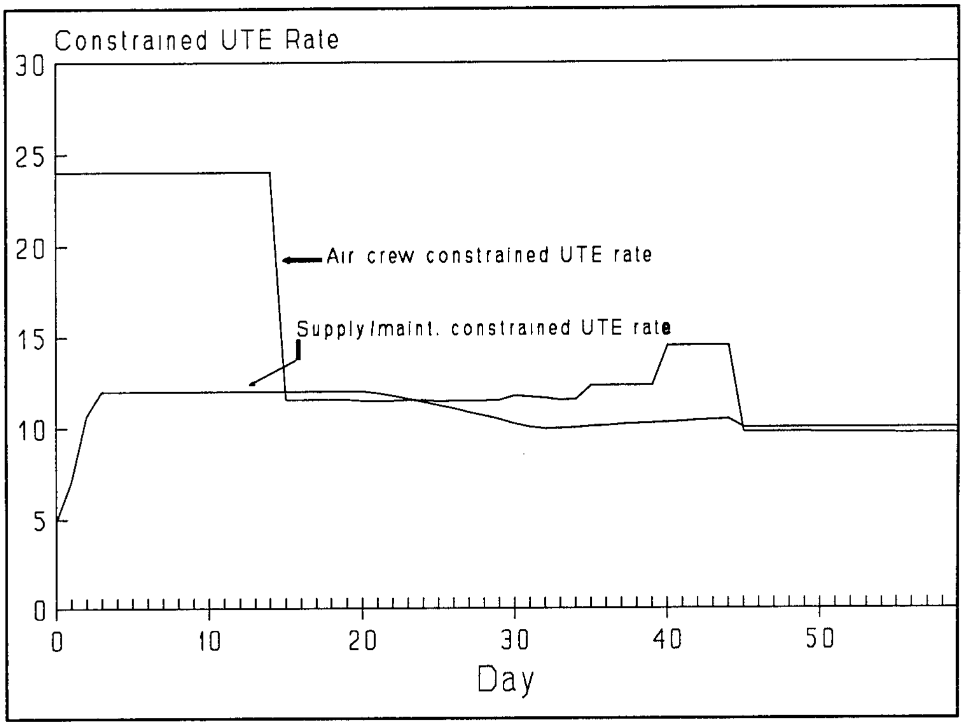

Figure 4-28. Aircrew Constraint on UTE Rates

The additional input parameters for the aircrew computation include the following:

- Crew ratio
- Crew availability
- Duty day (hours)
- Rest period (hours)
- 30-day flying hour limit per crew
- 90-day flying hour limit per crew
- Length of the unconstrained period (days)

4.2.3.12 ALAM Output Products

The primary output product of ALAM is the UTE rate table. However, other output variables are computed during the course of a run and are stored in arrays for either tabular or graphic output. The output data arrays are stored in ASCII format for easy access and creation of templates using Harvard Graphics software. The output arrays also include prespecified title, subtitle, and legend information that is used in the templating process for quick identification of each graphic output. An internal graphics feature is also available to enable the user to review output data on the screen. This internal graphics program will allow the user to print the screen view of the graph without exiting WINLAM and accessing a graphics package.

An additional feature of the output data structure is the ability to sequentially complete two model runs using different input data, store the results in comparison arrays, and then view the results on specifically constructed comparison graphics. This feature can be accessed by the internal graphics feature as well as through the templating process of Harvard Graphics or PowerPoint.

SECTION 5

ENVIRONMENT

5.1 EQUIPMENT ENVIRONMENT

Minimum WINLAM equipment requirements are an 80386-type microcomputer with 4MB of RAM and 10MB of available hard disk space. The model will automatically detect and access an 80x87 math coprocessor. The recommended system configuration is an 80386 with an 80387 math coprocessor or an 80486 and a 40MB hard disk. To produce hard copies of any graphics, a Hewlett Packard Laserjet Series I/II or compatible printer is required; text hard copy can be produced on any line printer. WINLAM will run on the AFWMAA/DSS hardware configuration.

5.2 SUPPORT SOFTWARE ENVIRONMENT

WINLAM is implemented using Microsoft C with the Microsoft Disk Operating system (MS-DOS) and Windows 5.1 on an IBM-compatible microcomputer. Software maintenance requires a Microsoft C compiler and MS-DOS Version 5.0 or later with supporting documentation.

5.3 COMMUNICATIONS REQUIREMENTS

Because WINLAM runs on a single microcomputer from a portable weapon system file, communication requirements during actual processing are unnecessary. Communication or movement of data is required only during the data collection stage of the model. Specifically, REMIS MC rate data are downloaded via modem from an online system and manually input into WINLAM.

5.3.1 HARDWARE

Currently, there are no requirements in WINLAM for data communications that require data communication hardware.

5.3.2 SOFTWARE

Currently, there are no requirements in WINLAM for data communications software.

5.4 INTERFACES

WINLAM operates in a stand-alone mode, interfacing only with FAMMAS.

5.5 SUMMARY OF IMPACTS

The present Air Staff analysis system will be affected organizationally, operationally, and developmentally due to the addition of WINLAM. While the full nature of the impacts is unknown, it is expected that the impacts will not result in functional realignment of major analysis responsibilities.

5.5.1 AUTOMATED DATA PROCESSING (ADP) ORGANIZATIONAL IMPACTS

Organizational impacts will result from the addition of WINLAM and will require AF/LGSI to coordinate with several Air Force offices to collect the input data required to perform analyses. This process will also have an impact on the offices from which the data are being requested. Section 2.4 discusses organizational impacts in further detail.

5.5.2 ADP OPERATIONAL IMPACTS

WINLAM's impact on ADP operations will vary by the nature of the user's roles and responsibilities. In most cases, however, WINLAM will probably be one of a number of systems sharing microcomputer resources. Users will need to learn how to operate the model, how to acquire and manipulate input information, and how to understand and apply the model's results within the scope of user responsibilities. Section 2.4 describes these operational impacts in more detail as they apply to the BPBBS process. Operational impacts related to employment of WINLAM in weapon system master planning can be expected to vary.

5.5.3 ADP DEVELOPMENTAL IMPACTS

The development of WINLAM should not require additional personnel or resources; however, personnel involved in the present analysis process will be required to collect resource information that already exists but is not presently accessed for analysis purposes. Once protocols have been established for the collection of this manually input information, impact on personnel involved should be negligible.

5.6 FAILURE CONTINGENCIES

In preparation for system failures, a working copy of the model and the associated data should be kept on floppy disks.

5.7 ASSUMPTIONS AND CONSTRAINTS

Underlying assumptions and constraints include the following:

- Certain WINLAM input will continue to be collected manually.

- WINLAM will be operated on microcomputers located in vaults or secure locations when operating with classified data. WINLAM will share these microcomputer resources with other applications.

SECTION 6
SECURITY

6.1 BACKGROUND INFORMATION

WINLAM variable names, formats, and all other computer program-related information are Unclassified. However, the data collected for official runs are classified Secret. Therefore, once classified data are entered into the model, only properly cleared personnel may have access to the model and the resulting output. For purposes of analyst training, dry runs can be made with notional data that are Unclassified. In this instance, the user needs no security clearance to view the model in-progress and its resulting outputs. The classified version of the model must run on a machine certified for classified data located in a classified area.

6.2 CONTROL POINTS, VULNERABILITIES, AND SAFEGUARDS

Two main control points must be considered in the WINLAM analysis process — input data and output results. Each of the sources must be considered in the hard copy and disk storage format. The vulnerabilities associated with these control points involve storage and use according to proper security markings and procedures. The safeguards necessary to avoid a breach of security when dealing with these specific control points are defined in the DOD security manuals.

6.2.1 CONTROL POINTS

6.2.1.1 Input Control Points

The manipulation of the input data needs to be controlled in several areas. The source from which the data are acquired, the means by which the data are transported from source to destination, and the storage of the data after reaching the destination all must be controlled by specific guidelines to ensure that no breach of security occurs. The steps followed when preparing and entering data must include storage on a properly classified machine, on properly marked and maintained disks, and on properly marked and handled hard copies. During data entry, it is important to classify the data correctly. Error correction is performed by the same process used for entering the data, and is subject to the same controls. Each file or collection of classified information in the WINLAM shall have an identifiable origin and use. Access to maintenance, movement, and disposition of classified information shall be governed on the basis of security classification, personal clearance level, and need-to-know. It is the *user's responsibility* to ensure that all input information is properly marked and maintained according to DOD security regulations.

6.2.1.2 Process Control Points

There is a possibility of error identification during the processing of the input data. This identification is confined to the machine processing the input data. Therefore, no outside controls need to be established. No system interfaces are required to pass or retrieve data during processing.

6.2.1.3 Output Control Points

Output devices used in conjunction with output data include any printers connected to the machine being used to process data. To ensure data security, proper markings must be used on both hard copies and disks containing output data, and WINLAM printers must be designated with the proper classification. Where distribution or presentation of output products is necessary, proper markings and methods of distribution must follow DOD security regulations. It is the *user's responsibility* to ensure that all output is properly marked. This is greatly simplified by accessing the appropriate menus within WINLAM and selecting the proper classification while engaging the model.

6.2.2 VULNERABILITIES

The points of vulnerability apply directly to the user of the input and output data. These vulnerabilities lie in the improper handling or marking of classified data in hard copy, disk storage, distribution, and presentation.

6.2.3 SAFEGUARDS

Safeguards against compromising classified information are defined in the DOD security codes and manuals listed in Section 1.2. These procedures encompass the needs of controlling points of vulnerability associated with the input and output data. All users of WINLAM information should possess the proper clearance and training to handle classified information.

6.3 SYSTEM MONITORING AND AUDITING

System monitoring and auditing are not automated. All monitoring is done manually by tracking input data in hard copy, in designated directories on all hard drives on the microcomputer, and on floppy diskettes that contain data files. Specific reports printed from WINLAM, as well as graphic displays and their accompanying text, are controlled manually by the user.

6.3.1 DOCUMENTATION

Journals kept for use in the WINLAM analysis process contain basic information concerning the changes to input data, notes used to maintain an organized structure to process data, and documentation of the output results aggregated for comparisons.

The journal is an informal means to track the steps taken in completing the analysis and producing the necessary output requirements. The journal can then be used to plan future analyses.

6.3.2 AUDIT TRAIL

There are no defined user requirements for an audit trail. The users can establish and save files of various versions of analysis data at their discretion. Any means or methods necessary to provide an audit trail for the analysis process can be established by model users. The process currently used is the journal of steps and notes for completing an analysis.

SECTION 7

SYSTEM DEVELOPMENT PLAN

This section provides a schedule of activities for the development of WINLAM. The approved FD will be used to support the following:

- Final development and testing of current WINLAM software to assure acceptable performance in a production mode using a production data base.
- Integration of WINLAM into the weapon system master planning process.
- Preparation and presentation of additional documentation as necessary in accordance with DOD-STD-7935A.

Detailed schedules for these development tasks will be provided as authorization and funding are realized. Until such time, monthly status reports will inform AF/LGSI of the work being accomplished on the model.

SECTION 8
COST FACTORS

Because WINLAM runs on a single microcomputer, its initial cost is limited. Most functional staff offices engaged in logistics analysis already possess or have access to appropriate hardware and software that would enable them to employ WINLAM. Therefore, no new cost factors are related to the proposed system other than those associated with the development plans described in Section 7.

APPENDIX A

WINDOWS INTEGRATED LOGISTICS ASSESSMENT MODEL DATA SOURCES

A-1 OVERVIEW

The Integrated Logistics Assessment Model automates the retrieval of data from a variety of sources through its File Management System (FMS). These sources are imported into a Paradox database through either ASCII text files or spreadsheet files.

The majority of the data is drawn from one of the following sources: REMIS, WMP, and Unit Cost Document. Each source is an Air Force-owned model or managed database. The following section gives a brief description of these sources and lists the Synergy point of contact (POC).

A-2 DATA SOURCES

A. REMIS – a historical database that provides mission capable rates (MC, TNMCS, NMCM), peacetime average sortie duration, and peacetime sortie rates by MAJCOM and MDS.

Information on access to this database can be obtained through Bill Faragher, Synergy, Inc. (202) 232-6261.

B. WMP (War and Mobilization Plan) – The FMS accesses the WMP-3 document for the deployment schedules by region of conflict and the WMP-5 document for the wartime sortie rates, wartime average sortie duration, and wartime attrition rates within each region. Both documents are broken by mission, design, series; scenario; and year.

Access to these documents is granted by USAF/XOXW, Maj J.R. Bryant, DSN 227-3707. This information is downloaded by John Moore and Kevin McCool, Synergy, Inc., (202) 232-6261, into an ASCII text file. The WMP database is classified Secret.

C. Unit Cost Document (UCD) – a spreadsheet generated by AFMC/FM, which contains the budget requirements and funding for RSD (replenishment and initial spares, and depot repair of spares), and SSD (consumables).

APPENDIX B

MISSION CAPABLE RATE

The aircraft mission capable rate is measured in terms of the ratio of the total hours aircraft are mission capable to the total hours aircraft are possessed by the using command over a given period. The MC rate is equal to one minus the not mission capable (NMC) rate, which can be expressed as the sum of the following six components, as specified by AFR65-110:

NMCS — not mission capable, supply (not airworthy)
NMCM — not mission capable, maintenance (not airworthy)
NCMB — not mission capable, both (not airworthy)
NMCSA — not mission capable, supply (airworthy)
NMCMA — not mission capable, maintenance (airworthy)
NMCBA — not mission capable, both (airworthy)

For the first three categories, the aircraft is restricted from any use, while for the last three the aircraft is able to fly but cannot perform any of its assigned missions. NMCM and NMCMA are each equal to the sum of NMC due to scheduled maintenance and NMC due to unscheduled maintenance. The total not mission capable, supply factor is given by:

$$TNMCS = NMCS + NMCB + NMCSA + NMCBA \qquad \textbf{[Eq B-1]}$$

Thus the MC rate can be expressed as

$$MC = 1 - (TNMCS + NMCM + NMCMA) \qquad \textbf{[Eq B-2]}$$

For purposes of this document, the parameter NMCM is used to denote NMCM + NMCMA, while the TNMCS parameter denotes the corresponding factor given in Equation B-1.